Technical Report 876

A Knowledge Elicitation Study of Military Planning

Marvin Thordsen, Joseph Galushka, Gary A. Klein,
Saul Young, and Christopher Brezovic
Klein Associates, Inc.

February 1990

United States Army Research Institute
for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

JON W. BLADES
COL, IN
Commanding

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Klein Associates, Inc.

Technical review by

Edwin R. Smootz
Robert E. Solick

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS --
2a. SECURITY CLASSIFICATION AUTHORITY --	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE --	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) KATR-863-C-87-08F	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARI Technical Report 876
6a. NAME OF PERFORMING ORGANIZATION Klein Associates Inc. 6b. OFFICE SYMBOL (If applicable) --	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute Fort Leavenworth Field Unit
6c. ADDRESS (City, State, and ZIP Code) Yellow Springs, OH 45387	7b. ADDRESS (City, State, and ZIP Code) P.O. Box 3407 Ft. Leavenworth, KS 66027-0347
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences 8b. OFFICE SYMBOL (If applicable) PERI-S	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-86-C-0170
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO.: 2P65502M PROJECT NO.: 770 TASK NO.: 144 WORK UNIT ACCESSION NO.: S6

11. TITLE (Include Security Classification)

A Knowledge Elicitation Study of Military Planning

12. PERSONAL AUTHOR(S)

Thordsen, Marvin; Galushka, Joseph; Klein, Gary A.; Young, Saul; and Brezovic, Christopher

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 86/08 TO 87/02	1990, February	70

16. SUPPLEMENTARY NOTATION

Mr. Rex R. Michel, Contracting Officer's Representative → Battle Field Management, ARTBASS

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Critical decision method, Content analysis, Decision making, Military planning, Distributed decision making, Knowledge elicitation,

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Critical Decision Method (CDM) has been developed as a knowledge elicitation tool for probing proficient decision making. This report describes the use of CDM during three different Division, Battalion, and Brigade-level planning exercises at Ft. Leavenworth, Ft. Riley, and Ft. Hood. CDM was successfully applied in each case. The third exercise, a computer-driven activity at Ft. Hood, used the Army Battle Training Simulator System (ARTBASS). It was the most complex and realistic of the exercises, and the CDM was supplemented by tapes of the operations planning activity. A microanalysis performed on these data generated 64 planning segments during a 5-hour period. The data showed a number of features of the operations planning process. Almost 93% of the information types used were directly accessible; there was little searching for additional information and not a single instance where data on enemy action were sought from S2 (Intelligence). In addition, most decisions were handled through recognitional strategies; in only 1 of 27 decisions was there a comparative evaluation of several options. The analysis of results was used (Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Rex Michel	22b. TELEPHONE (Include Area Code) (913) 684-4933 22c. OFFICE SYMBOL PERI-SL

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

ARI Technical Report 876

19. ABSTRACT (Continued)

to recommend features of training programs and decision support systems. In addition, a clearer concept emerged for using the CDM in conjunction with other data-gathering and analytic techniques.

in front of 1473, Blk 19, keywords

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Marvin Thordsen, Joseph Galushka, Gary A. Klein, Saul Young, and Christopher Brezovic
Klein Associates, Inc.

Field Unit at Fort Leavenworth, Kansas
Stanley M. Halpin, Chief

Systems Research Laboratory
Robin L. Keesee, Director

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

February 1990

Army Project Number
2P65502M770

Small Business Innovation Research—ARI

FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is committed to strengthening the understanding and training of the U.S. Army command and control. A part of this critical task is to develop methods of collecting and analyzing command and control performance data that will help identify areas that could benefit from enhanced training or aiding techniques.

This paper reports on the modification and application of an existing method to elicit knowledge about Army tactical planning exercises. This work is particularly valuable because of the depth of analysis applied to the planning session. The results identify potential planning process problems not typically discovered by more superficial methods.

EDGAR M. JOHNSON
Technical Director

A KNOWLEDGE ELICITATION STUDY OF MILITARY PLANNING

EXECUTIVE SUMMARY

Requirement:

To evaluate whether the Critical Decision Method (CDM) of knowledge elicitation can be used in Army Command and Control (C^2) exercises as a means of understanding decision-making dynamics. Such a tool could provide useful information about improving procedures and training as well as for specifying more effective decision support concepts.

Procedure:

The CDM was used during three different planning exercises. Analysis was focused on the most data rich and realistic of these exercises. A content analysis was performed on the exercise data, generating 64 planning segments during a 5-hour period. Each segment was coded for the dominant goals and the types of functions being performed. These data present a chronological record of the planning session organized by primary themes.

Findings:

Fully one-third of the transitions from one segment to the next were accidental, created by the typical interruptions of a simulated battle environment. Once the interruption was completed, planning rarely picked up from the same point. Ninety-three percent of the information used was obtained from sources immediately in the planning area and there was very little active searching for critical pieces of information that were not directly accessible. Twenty-six out of twenty-seven decisions made during the 5-hour session involved no comparison between options. Many of the probes used in the standard CDM post-exercise interviews were redundant with the planning information data gathered during the sessions. Moreover, the observations and tape recordings created a different and in many ways more accurate, record of option generation and evaluation than the retrospective CDM interviews. On the other hand, the CDM interviews uniquely obtained data about levels of proficiency. Such probes have been very informative about the differences between proficient and novice decision makers, and the data directly reflect training requirements. Such data are only obtained by the CDM, not by direct observation. We also developed three new methods for data analysis: the detailed content analysis of a planning session into a segmented situation assessment record; the overlaying on this record of data concerning the primary activities of each segment; and a technique for charting progressive deepening barriers that are identified, and strategies for overcoming the barriers.

Utilization of Findings:

The findings point out the need for better management of the team decision process and suggest a need for a different approach to decision-making training. Army centers and schools responsible for command and control decision-making training as well as line units can use these findings to help identify training requirements. They might also use the data analysis methods to evaluate performance and provide training feedback. Further, the findings are useful for command and control system designers in identifying where system improvements are required.

A KNOWLEDGE ELICITATION STUDY OF MILITARY PLANNING

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A KNOWLEDGE ELICITATION STUDY OF MILITARY PLANNING

Introduction

This report presents our findings about the use of the Critical Decision Method (CDM) for describing proficient performance within a battle management setting. We undertook this project to learn what type of information would be obtained using CDM, and to learn how we would need to expand our knowledge elicitation methods and techniques for data analysis.

The U.S. Army has a strong interest in how proficient decision makers function in complex environments, working under the time pressure and uncertain information that would exist on a modern battlefield. There is a need to develop a knowledge elicitation method that can be used in operational settings to capture decision-making performance.

The CDM is a knowledge elicitation technique developed under the sponsorship of the Army Research Institute for the Behavioral and Social Sciences. In 1985, Klein Associates was awarded a Phase I Small Business Innovations Research (SBIR) contract to study time-pressured decision making. The research studied urban fire ground commanders, analyzing the way they made decisions about the allocation of personnel and resources. The results showed that the great majority of decisions were made very rapidly, typically in less than one minute. The findings (Klein, Calderwood, & Clinton-Cirocco, 1986) supported a recognitional model of decision-making.

To perform the study we developed a knowledge elicitation method to describe the context-bound expertise of commanders with over 20 years of experience. The CDM technique we developed was a variant of Flanagan's (1954) critical incident approach, using our more specialized cognitive probes about decision-making strategies. The emphasis of CDM is on non-routine incidents where the differences between experts and novices may be contrasted most clearly. The probes largely deal with the cues relied on to formulate situation assessment and the types of options that are considered.

Phase II of the SBIR was planned to accomplish four goals, the research presented here comprising the third. The first goal was to present a formal description of CDM (Klein & MacGregor, 1988). The second goal was to evaluate the reliability of CDM. The reliability has been shown to be quite high, in the range of 60-90% agreement between independent raters (Taynor, Crandall, & Wiggins, 1987). The third goal was to assess whether CDM could be used within the constraints of an Army command and control (C^2) exercise. The fourth goal was the application of CDM for training and for decision support development and evaluation.

The following sections of this Introduction will describe the battle management environment and CDM, and briefly review some earlier research studies using CDM.

The Battle Management Environment

Battle management here includes the tactical planning for battle. The planning staff consists of the various officers and their staffs. G3 (Operations) and G2 (Intelligence) personnel are the main participants in this planning process, but G4 (Logistics), G1 (Personnel), and all other staff elements take active roles. The Commander is responsible for taking all staff inputs and coming up with a final plan.

Much planning occurs well ahead of any battle, and the larger and more likely the battle the greater this prior planning. However, as the battle nears there is always significant adjustment to the original plan as current conditions evolve. There is also the ongoing requirement to conduct the battle itself and to perform the requisite planning during the engagement.

We have given these phases different names, as they appear to constitute quite different planning and decision-making environments. The planning that occurs well before the battle we identify as Long Term planning. For our purposes this phase can be considered to begin from months to years, and to end from days to weeks before the actual battle. It is characterized by a relatively leisurely pace of planning, at least as compared to the following two phases. The sort of contingency planning done by Pentagon staffs is typical of Long Term planning. The replanning and adjustments to current conditions that occur just prior to commencement of the battle we identify as Near Term planning. This takes place a few days, up to perhaps a few weeks, prior to start of a battle. It is characterized by increasing time pressures and an increased flow of information concerning events surrounding the immediate battle environment. Finally, the replanning and execution of the battle during its actual conduct we identify as Immediate planning. The environments that were investigated and reported on here were the latter two: Near Term planning and Immediate planning.

The Near Term and Immediate battle management environments are characterized by increased confusion, conflicting information, decreased time for planning, and an overall sense of immediacy and increased pressure. This is also a highly distributed decision-making environment involving numerous individuals, each with a functional area of responsibility, and all charged with working together to produce a coordinated plan.

The Importance of Knowledge Elicitation in the Battle Management Environment

Background research into the decision-making literature, (Klein, in press) indicated the difficulties encountered in coming to grips with just how proficient decision makers function in their domain of expertise. Laboratory experiments with domain experts have been disappointing because much of the richness of the domain cannot be carried across into the laboratory setting. The very definition of experts includes the ability to make good choices in complex and confused environments. The way to understand and analyze experts doing their jobs seems to consist of two parts. First, the analyst must observe proficient decision makers while they are performing their tasks in the natural environment. Second, the analyst must develop and employ a data collection that is as invisible and unobtrusive as possible. The goal is to

elicit as much detail and information from the experts as possible, while leaving the tasks unchanged. It is usually impossible to determine from observation alone just what is going on in the expert's mind.

The distributed nature of this planning and decision-making process also deserves comment. Operational planning is typically a group process and the participants may be at several different physical locations. Radios and telephones are used to communicate among these locations. Periodically all staff elements are brought together for briefings and, as necessary, for other events.

We will now present a brief description of the CDM in the following section. For a more detailed examination of the method see MacGregor and Klein (1988).

Critical Decision Method

The Critical Decision Method employed in this study was developed to extract from individuals working in complex, real world domains the important turning points in domain-specific situations, i.e., the ones the person felt were critical to the eventual resolution of the situation.

The goals of CDM are to be both as non-intrusive and as extractive as possible in the situation and to draw from the expert or novice the important aspects of his knowledge and decision making in the domain. CDM was originally developed by a team of researchers representing the disciplines of cognitive psychology, communications, and anthropology.

One example of CDM application is based on a study of tank platoon leaders at Ft. Knox, Kentucky, in 1986-87. The results of this study have been reported in detail in Brezovic, Klein, & Thordsen (1987). The situation was the training of Army tank platoon leaders, junior grade officers who were involved in field exercises which pitted their platoon of tanks against "enemy" tanks. Accompanying each tank crew was an Army non commissioned officer (NCO) who was himself a tank commander and had considerable experience in the field. These NCOs functioned as instructors and would be considered experts in this domain.

Researchers accompanied the tank crews, with one researcher riding in the platoon leader's tank, observing the unfolding action and commenting into his tape recorder when appropriate. These comments also formed the basis for later knowledge elicitation and critical decision identification during brief interviews conducted immediately after each field exercise. Another researcher accompanied the officer instructor who set up and executed each field exercise.

During brief breaks after each exercise one researcher would interview the novice, and the second researcher would interview the expert. Both would employ a set of CDM probes that asked a number of questions such as: What do you think were the most difficult and challenging decisions faced in this exercise? If you had to rank these decisions in terms of learning importance, how would you rank them? For each decision point, what did you do? Suppose you had to describe the situation of this decision to a friend of yours--would you say to him in 25 words or less? Were there any other options available in addition to what you decided? What factors would have made you reject the option you had chosen?

CDM focused on the critical points in the situation which stand out in the participants' minds as particularly important. Then, the participants were asked to describe the situation surrounding these important decision points. Finally, the participants were asked to describe what cues they focused on to decide upon a course of action. Notice that we have moved from eliciting the critical decision points, to eliciting the general situation surrounding each critical decision point, to finally eliciting an assessment of the situation. This entire series of queries is the CDM.

CDM as currently employed has evolved to the point where it can now be used coincidentally in the domain being investigated, as with the tank study, or after the fact, based on interview notes and audio tape recordings, as in the current study.

One important finding already obtained with CDM is that, as hypothesized, the experts were much more often making decisions based on a recognition-primed process, and much less often by generation of alternatives and simultaneous evaluation (what can be called a concurrent deliberation basis). Conversely, novices in identical situations are much more likely to make decisions based on the generation and concurrent evaluation of alternatives, and much less likely to choose solutions on a serial, recognition-primed basis (Klein, in press).

In the battle management domain, it seems important to recognize that we have experts making time-critical decisions in a distributed decision framework. The importance of applying CDM in this complex, time-critical domain is to help determine training agendas that will more rapidly and efficiently upgrade the skills of novices to levels of competence and proficiency.

Method

The CDM was applied in three settings: at Ft. Leavenworth, Kansas in a division and corps classroom setting, at Ft. Riley, Kansas in a field training brigade exercise, and at Ft. Hood, Texas in a computer driven, battalion exercise.

Ft. Leavenworth

This was a classroom training exercise at the Command and General Staff College located at Ft. Leavenworth, Kansas. The observations occurred over a three day period in December 1986. The setting was corps and division planning based upon an American geographical scenario. There were approximately 1[illegible] individuals in the class. Most participants were majors in the regular U.S. Army. Exceptions included one Air Force captain, one Marine major and one Greek Regular Army colonel.

The training scenario involved the planning of a counterattack against Soviet Threat forces that were occupying the United States. The students had approximately two days to develop a plan for the counterattack.

One primary goal for this data collection was to give the researchers direct experience with some of the issues and terminology involved in the military planning process. As with most knowledge elicitation methods, a certain amount of domain information is required and this was a first attempt to gain some.

Two researchers observed the exercise. One focused upon the events that took place within the G3 section (operations and plans) and the other focused upon the G2 section (intelligence). Notes were taken and briefings were audio-taped. The researchers conducted sort interviews using CDM when the planners within these sections took breaks. Examples of the two interview guides employed in these sessions for the G2 and G3 are in Appendix A.

In our opinion, the CDM worked well capturing the processes taking place, with one necessary qualification. Our desire was to apply CDM in a realistic planning environment. This operation was a classroom exercise to train planning skills. Therefore, we can only comfortably say that a classroom process was captured. Although the setting addressed corps and division-level planning, it contained several artificial elements and lacked some realistic ones which affected the functional nature of the process. Some of these were the absence of real and continuous time planning, and the presence of "game rule" changes for the sake of instruction, all of which affected the overall sense of realism of the exercise.

Nevertheless, the observation was profitable in helping confirm that the CDM approaches used for collecting data in previous studies could be modified for the battle management planning environment.

Ft. Riley

This was a National Guard field exercise conducted at Ft. Riley, Kansas. The observations occurred over a three-day period in May and June of 1987. The setting was a brigade field tactical operations center (TOC) and the exercise was based upon a Western European geographical scenario. The exercise was driven by a combat board training game. A combined S3 and S2 section was observed. Most participants were captains and majors in the National Guard.

The context of the training scenario was the planning of an offensive maneuver against Soviet Threat forces. The battle took place over a two-day period.

Two researchers observed the exercise. The initial plan was to have one focus upon the events taking place within the S3 (operations and plans) and the other upon the S2 (intelligence). Notes were taken and occasional briefings were audio-taped. When the planners had available time, the researchers conducted short CDM interviews. Examples of the interview guides used for these sessions are in Appendix A.

Although this exercise avoided some of the limitations of the Ft. Leavenworth classroom setting, it raised another difficulty. Simultaneous with this exercise, another maneuver was being conducted and many of the personnel assigned to this operation were abruptly reassigned to the other, leaving this brigade TOC understaffed. There was one officer who was present throughout the entire exercise. Often he was the only individual working in either intelligence or operations. He assumed responsibility for S3 and S2 tasks as well as for occasional air and fire support. The result was that most of his time was spent monitoring the progress of the "battle" with virtually no time available for planning.

We found this trip profitable since we were able to use various aspects of the exercise to modify CDM to better suit the military planning environment.

Ft. Hood

This was a simulation-driven training exercise of a Regular Army infantry battalion conducted at Ft. Hood, Texas. The observations occurred over a three day period in June of 1987. The setting was the battalion TOC and the exercise was based upon a Western European geographical scenario. There were upwards of 25 participants in the TOC as well as another 25 individuals running the exercise from the computer center. At any given time the TOC staffing averaged four to five individuals in the S3 shop and two to three in the S2 shop. Most participants were captains and majors.

The context of this training scenario was the execution of an attack against Soviet Threat forces on day one, the development of a defensive plan on day two, and the execution of that plan on day three.

This exercise was devoid of most of the problems encountered in the first two trips. The scenario was driven by the Army Training Battle Simulation System (ARTBASS), a computer-based, training aid that allows the input and maneuvering of resources (friendly and enemy) over a digitized terrain map. The system can track all phases of the battle and determine the outcome of fire fights, artillery and air missions, ammunition used and remaining, speed of movement, etc. It should be noted that the individuals in the battalion TOC, who were set up in a simulated field setting, did not have access to these machines. The computers were in another location and information was input and read by individuals serving in the roles of the brigade commander (above the battalion) and the company commanders (below the battalion). The messages between the brigade and company commanders (both of whom were interfacing with the computer) and the battalion TOC (no computer) were transmitted via radio.

Two researchers observed the exercise. One researcher focused upon the activities of the S3 section and the other watched the S2 section. Notes were taken and occasional briefings were audio-taped. When the planners had available time, the researchers conducted interviews using the CDM. Examples of interview guides used in these sessions are in Appendix A.

Data were collected for all three stages of the planning mentioned above. One particular stage (five hours of developing a defensive battle plan) was extremely rich and conducive to the knowledge elicitation method and subsequent analysis.

During the course of this stage, most of the planning was conducted by open discussion among two to ten individuals who were gathered around the S3 map. The researchers placed a small tape recorder directly in front of the map and recorded the entire course of discussion from which the plan emerged. Additionally, during short break periods, available participants were questioned about aspects of the plan. It should be noted that during this planning session, while S3 was amply staffed, the S2 section often consisted of only one or two individuals. The result was that although we were able to record the actual planning of the S3 section, the intelligence work often involved one individual examining the S2 map and making silent observations. Therefore the

majority of the data are from the S3 section perspective. Although additional data were collected, it was decided, due to differences in the nature of these data, to center the primary analysis around the transcripts from the five hours of S3 planning.

Data Analysis

At this point we faced a decision about allocating our own resources. We had collected a large amount of data during the trips to Ft. Leavenworth and Ft. Riley. Most of these data had not been analyzed by the time we had the opportunity to observe the ARTBASS exercise at Ft. Hood. The data collected at Ft. Hood turned out to be the richest source of data of all.

One alternative was to try to analyze some data from each of the observation sites. Another was to abandon the data from the first two sites, and concentrate on the Ft. Hood data. We chose the latter option.

Our justification was that the Ft. Hood exercise was the most realistic, the closest to typical Army exercises, and the one from which we could learn the most. The Ft. Leavenworth and Ft. Riley exercises were each limited in important ways. Moreover, CDM data had already been successfully collected at Ft. Leavenworth and Ft. Riley. We had been able to conduct the interviews as in our own earlier research, to ask the same questions, and use the same probes. If anything, these data collection efforts were even easier than the Ft. Knox study where we had been limited to 10-minute interviews with the tank platoon leaders. We knew that we could do the same data analyses that we had used earlier, cataloguing critical cues and aspects of situational assessment that emerged through the interviews.

For these reasons we chose to concentrate all of the analytical resources on the Ft. Hood exercise. We wanted to study the audio tapes of the planning session and to develop new methods of analysis to handle these types of data. Our goal shifted from simply demonstrating that we could conduct CDM interviews, to pushing our analytical techniques further to capture real-time planning dynamics.

A transcription was made of the five-hour planning session. These transcripts served as a direct timeline of events from the defense planning session. A general flow of the planning session began to emerge during the analysis of the transcripts. Each phase of the analysis was developed independently via input from researchers who were at the exercise and those who were not. The intent of using two independent analyses was to provide an unbiased check on the quality of the products.

The first level of analysis involved providing a simple timeline of identifiers which could be used to follow the flow, and also locate information in the transcripts. Sequencing and continuity were deemed the most important properties to be preserved by this process. Long sheets of computer paper were used to "map out" the development of the plan. This enabled us to visualize sequencing as well as similar references of information through time. Further, it served as the basis for what later will be referred to as the "segments" of the planners' objectives.

There are important factors in military settings that affect how the plans are developed: missing information, uncertainty with existing information, and confusion as to the state of the existing plan. Capturing these elements may be one of the key issues which is not addressed by traditional approaches to military and corporate decision making. By developing a visual representation of the process as it evolved we were one step closer to identifying these factors. Therefore, our next step in the analysis was to monitor the focus of planners through time and to attempt to label these foci in terms that were specific to the military domain.

We proceeded to track the general flow of events through time, and then attempted to break out the content-specific foci the planners were addressing. Through the initial readings of the transcripts, a few of the elements became obvious. For example:

- friendly strategy: What about this, I've got an obstacle here, it's an open area for Delta [company] to come in and engage...
- engineering efforts: I [the engineer] can give you three battle positions, but I'm going to need at least two more dozers...
- scouting efforts: [Scouts] will be on a forward screen line, early warning...
- commander's intent: The Colonel [Commander] wants to defend in depth, so I'm just giving these guys areas to orient on to fire...

Elements which were not so obvious also began to emerge when this categorizing of foci was employed. Examples of these include:

- problem recognition: We're going to corner him [a friendly element], we're talking lives here.
- general planning issues: You want me to throw this movement overlay here?

The real difficulty lay in not forcing elements into categories yet exhaustively representing the "real concerns" and foci of the planners. Operationalizing these elements was an iterative process which required many hours of deliberation.

Next we tried to track direct references to information in the transcripts and then see if they reoccurred and if they did whether they reoccurred within the same context. To accomplish this it was necessary to number each unit of information as it occurred in the transcripts, then evaluate whether the information was already in existence from a previous context or discussion.

It is from these analytical approaches that the following results were obtained. An excerpt from the data map of the five hour planning session is presented in Appendix C.

Results

The analysis focused on the following key areas:

(a) Results of the C^2 Analysis.

1. Segments of the Plan and Segment Objectives.
2. Reference Units and Reference Unit Foci.
3. Functional Processes Employed by the Planners.
4. Higher Order and Sub-Goals.
5. Decision Making.
6. Option Generation.
7. Information Seeking and Acquisition.
8. Nature of Transitions Between Segments.
9. Progressive Deepening.

(b) Assessment of CDM.

1. Critical Decision Methodology Applications in Military Setting.
2. Modeling Group Decision Making.

Results of the C^2 Analysis

Segments of the plan and segment objectives. There were 12 primary areas of focus (objectives) on which the planners concentrated. Each occupied from 1-to 20-minute periods averaging approximately 4-1/2 minutes. These can be viewed as the themes of sections of the planning process. For example planners may have spent 10 minutes working out a subplan for the use of obstacles. This effort did not generate the entire obstacle plan; it was the objective on which they focused their attention during that period of time. This 10 minute period would be classified as a segment of functional focus with "obstacles" being its objective. If this same objective was readdressed later, it would be treated as a separate segment, even though the nature of the objective would be the same (obstacles). In other words, if there are two occasions where they deal with obstacles it was coded as two separate segments sharing an objective. Appendix B provides a sample of the transcript with segments marked.

The operational definitions for coding the segment objectives were as follow:

COMMANDER'S INTENT: A direct attempt to interpret and/or satisfy the commander's intent.

OBSTACLES: Planning the use and placement of obstacles.

ROUTES AND POSITIONS: Determining appropriate routes in and out of the battle areas and potential positions for the friendly elements.

RECONNAISSANCE, SCOUTS AND FORWARD PATROLS: The use, withdrawal, or safety of reconnaissance, scouts, and forward patrols.

RESOURCES: Determining the availability of adequate quantities of resources including tanks, trucks, mines, personnel, air support, artillery, bulldozers, etc.

ENEMY HYPOTHETICALS AND PLANS: Consideration of potential enemy strategy, movements, resources, attributes, and options.

ENGINEERING: Consideration of the engineering work necessary to establish the friendly, pre-battle layout of obstacles, positions, demolitions, etc.

FIRE SUPPORT: The establishment or use of fire support such as artillery.

AIR SUPPORT: The establishment or use of air resources and support.

FRIENDLY STRATEGY AND HYPOTHETICALS: Offensive or defensive planning and contingencies concerning the friendly forces under the command of this headquarters.

MOVEMENT OF FRIENDLY TROOPS: The movement of friendly troops from a previous battle sector into the current sector's primary battle positions.

GENERAL PLANNING AND "HOUSEKEEPING": The process mechanics of developing the plan.

Table 1 shows the breakdown of the number of segments which concentrated on each of the 12 objectives.

Table 1

Frequencies of Segment Objectives

Objective	Number of Segments
Friendly strategy and hypotheticals	14
Obstacles	9
General planning and "housekeeping"	9
Engineering	8
Recon, scouts, and forward patrols	6
Commander's intent	5
Routes and p· .itions	5
Fire support	4
Enemy hypotheticals and plans	3
Resources	2
Movement of friendly troops	2
Air support	1

To help examine the sequence of the segment objectives through the course of plan development, the objectives were mapped onto the main data sheet (Appendix C). As might be expected, the planners did not always address these objectives separately. There were 64 individual segments. In 60 of the segments, single objectives were "in the spotlight" (e.g., obstacles, resources, etc.) while in the remaining four, double objectives were addressed (e.g., obstacles and engineering, friendly strategy and enemy strategy, etc.). There did not appear to be any set pattern as to which objective would follow any other.

In addition to the segments and objectives described above, the transcript data were categorized within eight additional parameters. First the transcripts were divided into 230 discrete units which were labeled reference units. These were the smallest units of the transcripts which retained any context of the discussions. Each of these units generally had at least one of 18 specific foci. These reference units and their foci will be addressed in the next section.

Each of the reference units were also examined and coded for the types of operational processes taking place in them. It was found that the activities could be categorized into any of six types of processes: introduction of information, appraisal of information, generation of options, decision making, refinement of previous decisions, and general housekeeping or clarification activities. These process categories are defined in a later section along with the analysis performed upon them.

Other analyses were conducted examining the goal structures employed by the planners, the nature of (reasons for) transitions between the segment objectives, and the issue of progressive deepening. Following these transcript analyses, CDM was assessed along two dimensions: its applications in military settings and its use in modeling distributed decision making. It should be clarified that while the military planning environment is considered distributed, these data came from one observed central location in the process (the S3 section). These analyses and assessments will now be addressed separately.

Reference units and reference unit foci. While the 64 segments of the plan were the primary focus of our analysis, we divided the entire transcript into a number of smaller units to simplify referencing the transcripts and to aid in a more detailed analysis. These "reference units" generally embodied verbal interactions regarding a specific subject, or focus. They differed from segments in that a segment consisted of all contiguous discussions intended to meet some objective, such as planning the movement of a friendly unit. Reference units, on the other hand, consisted of more narrow topics and topic changes within a segment. For example, discussing the scouting and reconnaissance of possible routes might be a reference unit within the broader segment of planning the movement of a friendly unit.

These reference units consisted of sections ranging from one sentence to four or five paragraphs. The average was about one paragraph of transcript. The final total of reference units was 230 with the average unit accounting for approximately 1.25 minutes of planning (range: 15 seconds to 10 minutes).

Although these breaks were somewhat arbitrary, we attempted to have them represent the smallest units of the planning that could be identified from the transcripts. The 64 segments generally included from 2 to 15 of these reference units. An example of a section of the transcript with its segments and reference units labeled is included in Appendix B.

While the planners concentrated on the 12 objectives of the previously mentioned segments, their moment-by-moment attention switched between 18 smaller areas of focus within the reference units. Each reference unit generally had at least one of these issues on which it focused. You will find some of the objectives and foci with duplicate labels because there was overlap in the content of the 12 objectives and the 18 areas of focus. For example, while in the middle of a ten minute discussion about obstacle placement (the objective) the planners briefly focused on the meaning of the commander's intent--"He wants us to mine this avenue" (the area of focus). Here the focus (commander's intent) was within the context of the objective (obstacle placement). At a later time the objective of a different ten minute discussion was completely about the commander's intent, e.g., the commander was present and gave additional direction. In the former segment, the commander's intent was one of the 18 areas of focus, while in the latter it was the segment objective.

These reference units and reference unit foci can be thought of as minor, subareas of discussion within the segments that in and of themselves are not complete enough to stand on their own. For example, a segment may involve a ten minute discussion about moving a battalion from location A to location B. The reference unit and reference unit foci may include a one minute subdiscussion concerning the use of check points, another two minute sub discussion concerning specific routes to take and so forth. The reference units are not complete enough to "stand on their own" and they only have meaning and impact within the framework of the overall section.

Working directly from the transcript, coders identified the foci of each reference unit. The operational definitions for the coding of these foci are as follow:

COMMANDER'S INTENT: The giving of orders by the commander or the staffs attempt to interpret those orders.

FRIENDLY STRATEGY: References to offensive or defensive planning and contingencies of the friendly forces under the command of this headquarters.

TIMING: Specific references to issues where the time of execution is a critical element to success.

SCOUTS AND RECONNAISSANCE: References to issues concerning scouting, reconnaissance, forward observation and the safety of these efforts.

OBSTACLES: Reference to any object or barrier, whether natural or man-made, that the planners were considering using as an impediment to the movement of enemy forces.

TERRAIN: Natural characteristics of the land including topography, rivers, vegetation, etc.

RESOURCES: Specific references to availability of adequate quantities of resources including tanks, trucks, mines, personnel, air support, artillery, bulldozers, etc.

ENGINEERING EFFORTS: References to the engineering work necessary to establish the friendly, pre-battle layout of obstacles, positions, demolitions, etc.

ROUTES: Considerations of avenues of ingress to and egress from the battle area.

POSITIONING: References to placement of specific elements on the primary and subsequent battle areas.

ENEMY STRATEGY: References regarding the potential strategy and options that enemy forces may employ and how this might be affected by the elements' size, number, and attributes; the avenues of approach; resources; terrain; etc.

OTHER FRIENDLY FORCES: Consideration of other friendly elements in adjoining sectors.

GENERAL PLANNING AND "HOUSEKEEPING": Issues concerning the process mechanics and semantic elements of developing the plan.

SOVIET DOCTRINE: References to standard anticipated actions of the enemy forces as prescribed by friendly military manuals and training.

LOGISTICS: Issues which relate to stocking, equipping, and transporting supplies, resources, materials, etc. to the friendly elements.

ARTBASS: Direct reference to the rules and limitations imposed on the exercise scenario by the computerized Army Training and Battle Simulation System.

WEATHER: Direct reference to influences of weather.

RECOGNITION OF PROBLEMS: Identification of potential problems.

Table 2 shows the relative percentages of occurrence of these foci, in order of appearance during the planning process.

Table 2

Frequency of Occurrence of Reference Unit Foci

Foci	Frequency	Percent
Friendly strategy	107	20.0
Terrain	48	9.0
Obstacles	45	8.4
Commander's intent	43	8.0
Routes	37	6.9
Resources	36	6.7
General planning and "housekeeping"	36	6.7
Enemy strategy	31	5.8
Positioning	30	5.6
Scouts and recon	28	5.2
Engineering	28	5.2
Timing	20	3.7
Logistics	14	2.6
Recognition of problems	14	2.6
Other friendly forces	5	0.9
ARTBASS (scenario driver rules)	5	0.9
Weather	5	0.9
Soviet doctrine	4	0.7
Total	536	100.0

Not surprisingly, the area to which the planner's attention was directed most often was friendly strategy (20%), followed by terrain (9%), obstacles (8.4%) and commanders intent (8%). General planning and "housekeeping" issues appeared more often than enemy strategy, almost twice as often as timing issues, and nearly three times more than logistic and recognition of problem issues. Weather, other friendly forces and Soviet doctrine were nearly non-existent. It is interesting to note that recognition of problems was the last foci introduced. For example: if the planners follow through with a particular option for the friendly movement from one location to another, many of the troops will get lost if they are not provided checkpoints. This appeared approximately 2 hours into the planning process.

Functional processes employed by the planners. We identified six categories of the processes taking place within each reference unit of the transcripts. These included a) the introduction of information (new and old), b) the Generation of options, c) the appraisal of information, options, etc., d) decisions made, e) the refinement of previously made decisions, and f) clarification of issues, processes, etc. which did not advance the plan in any way.

We coded each reference unit by the functional processes which took place, the order in which they took place, and repetitions. The operational definitions used for the coding of these categories with examples follow:

Information: Any pieces of information introduced into the planning environment. This information does not have to be used by the planners, as long as it is technically available for their use and if used, could further the state of the plan. For example: "(We have) four planes, two on strip alert which is 30 minutes, two on standby alert which is immediate."

Generation: The generation of options and alternatives by the planners. For example: "You drop (artillery) here, here, here, here...up until the time when you don't want to drop it anymore."

Appraisal: Any general discussions, debates, arguments, etc. that the planners took part in, that served to further the state of the plan. This sometimes included "kicking a dead horse" discussions, since we judge these helped the individual planners further their understanding of the plan even if it was something of a lost cause. For example: "(It depends) on where you want to put it, what the defenses look like, direction of wind, hazard conclusion analysis for chemical--also because once we throw it they are going to throw it."

Decisions: Any decision that is clearly made with the authority of rank or with the consensus of the decision group supporting it. For example: "No, send them down to, up out of bounds, right there, back up, stop, cut them off right there, straight down into the section..."

Refinement: Any "fine tuning" of a previously made decision. For example: from above decision,

A: You want the road junction right here?
B: Yeah, 800.
A: 800, 870.
B: How do you all give out routes, do you want to give out a route like that overlay?
A: We'll probably have to, that's a pretty substantial move.

Clarification: Any process which primarily serves a purpose of general "housekeeping" or covering "old ground" for someone who just came into the session, etc. A requirement of this category is that it does nothing to further the current state of the plan. For example:

A: Do you want a map size overlay of the route or do you want me to draw it on an 8 x 11 sheet of paper?

B: No, put it on something that they can put on a piece of acetate that they can put on their map.

Table 3 gives the frequencies of occurrence of these six categories.

Table 3

Frequencies of Functional Planning Processes

Category	Frequency	Percent
Appraisal	225	38.8
Information	164	28.2
Generation	102	17.6
Clarification	40	6.9
Decision	27	4.7
Refinement	22	3.8
Total	580	100.0

Two-thirds of the planning process involved introduction of information and appraisal, while almost one-fifth involved generation of options. The remaining 15% was divided among decision making, refinement of the decisions, and clarifications.

Table 3 reflects only the frequencies of occurrence, not the amount of planning time occupied by each of these processes. The judgment of the researchers for the relative magnitude of planning time required for the six categories, is:

APPRAISE > GENERATE > INFORMATION = REFINE = CLARIFY > DECISION

Higher order and sub-goals. The planners worked within a framework of two overriding goals:

(1) Deny the Enemy Phase Line Hawaii.
(2) Deny the Enemy Phase Line Hawaii by killing them.

While these were undeniably the overriding goals, they were of such a high order that they were not often directly addressed. We therefore chose to look at the sub-goals operating under these two primary goals.

Within the two overriding goals, the planners were driven by eight sub-goals, most of which had multiple sub-sub-goals. The eight sub-goals and their sub-sub-goals were arrived at by identifying the specific goal of each reference unit (the smallest unit of the transcript). This was accomplished through four readings of the transcript. The first pass was "open" in that the coders began with no predetermined goal categories and identified the goals that each reference unit seemed to satisfy. The second pass reassigned units to more appropriate specific goal categories. This was necessary in light of the fact that the first pass generated additional categories as the coding progressed.

The third and fourth passes were conducted to assure the coder that the appropriate goal(s) was assigned to each reference unit. The eight identified sub-goals were:

(1) Determine where the enemy was coming.

(2) Determine when the enemy was coming.

(3) Slow the enemy's advance.

(4) Canalize the enemy.

(5) Allow the withdrawal of friendly troops.

(6) Move friendly troops to new battle positions.

(7) Establish the friendly defensive strategy.

(8) Accommodate the Commander.

Table 4 outlines the entire goal structure with accompanying statements of the outlined goals. The frequencies and percentages are presented in Table 5. Note that the values presented in "Each" column of Table 5 do not overlap. For example, there were 12 occurrences where the sub-goal was "determining when the enemy was coming." These were separate occurrences from the 10 when the sub-goal was to "use scouts to determine when the enemy was coming," and so forth. That is, there were times when a sub-goal was discussed without mentioning specific sub-goals. The "Sum" columns however reflect the summation of <u>all</u> occurrences within a particular sub-goal.

Table 4

Goals and Goal Statements

Outline	Goal Statement
(Deny P/L Hawaii)	Do not let enemy reach Phase Line Hawaii
(Kill enemy)	Kill enemy to keep them from P/L Hawaii
(With Indirect)	Use indirect fire - kill enemy to deny P/L Hawaii
(With Direct)	Use direct fire - kill enemy to deny P/L Hawaii
1. Where Enemy coming	1. Determine where enemy is coming
1.1 Use Scouts	1.1 Use Scouts to determine where enemy is coming
1.2 S2	1.2 Use S2 to determine where enemy is coming
1.3 Terrain	1.3 Analyze terrain to determine where enemy is coming
2. When Enemy coming	2. Determine when enemy is coming
2.1 Use Scouts	2.1 Use scouts to determine when enemy is coming
2.2 Use S2	2.2 Use S2 to determine when enemy is coming
3. Slow Enemy	3. Slow the advance of enemy
3.1 Use obstacles	3.1 Use obstacles to slow advance of enemy
3.1.1 Use Bridges	3.1.1 Turn bridges into obstacles to slow enemy
3.1.2 Mines/FASCAM	3.1.2 Use mines/FASCAM as obstacles to slow enemy
3.2 Use artillery	3.2 Use artillery to slow enemy
3.2.1 Chemical	3.2.1 Use chemical artillery to slow the advance of enemy
4. Canalize Enemy	4. Canalize enemy
4.1 Use obstacles	4.1 Use obstacles to canalize enemy
4.1.1 Use Bridges	4.1.1 Turn bridges into obstacles to canalize enemy
4.1.2 Mines/FASCAM	4.1.2 Use mines/FASCAM as obstacles to canalize enemy
4.2 Terrain	4.2 Use natural terrain to canalize enemy
4.3 Artillery	4.3 Use artillery to canalize enemy
5. Allow withdraw	5. Allow friendlies to withdrawal
5.1 Use obstacles	5.1 Use obstacles to help friendlies withdraw
5.2 Artillery	5.2 Use artillery to help friendlies withdraw
5.3 Routes	5.3 Determine routes for friendly withdraw
5.4 Scouts Withdrawal	5.4 Allow friendly scouts to withdraw

Table 4 (Continued)

Outline	Goal Statement
6. Forward Movement	6. Allow forward movement of friendly units
6.1 Routes	6.1 Determine routes for forward movement of friendly units
6.1.1 Checkpoints	6.1.1 Use checkpoints to mark routes for forward movement
6.2 Resources	6.2 Determine resources necessary for forward movement
7. Establish Friendly Defense	7. Establish friendly defensive position
7.1 Use Terrain	7.1 Use terrain to help establish friendly defense
7.2 Use Obstacles	7.2 Use obstacles to help establish friendly defense
7.3 Use Engineer	7.3 Use engineering assets to help establish friendly defense
7.3.1 Protect Engineer	7.3.1 Protect engineers establishing friendly defense positions
8. Accommodate Cmdr	8. Please the commander

Table 5

Frequencies of Sub-Goals and Sub-Sub-Goals

Goal	Frequency Sum	Frequency Each	Percentage Sum	Percentage Each
1. Where Enemy coming	26	12	10.4%	4.8%
1.1 Use Scouts		10		4.0
1.2 S2		2		0.8
1.3 Terrain		2		0.8
2. When Enemy coming	10	2	4.0%	0.8%
2.1 Use Scouts		7		2.8
2.2 Use S2		1		0.4
3. Slow Enemy	35	5	14.0%	2.0%
3.1 Use obstacles		7		2.8
3.11 Use Bridges		7		2.8
3.12 Mines/FASCAM		11		4.4
3.2 Use artillery		3		1.2
3.21 Chemical		2		0.8
4. Canalize Enemy	45	9	18.0%	3.6%
4.1 Use obstacles		8		3.2
4.11 Use Bridges		15		6.0
4.12 Mines/FASCAM		7		2.8
4.2 Terrain		4		1.6
4.3 Artillery		2		0.8
5. Allow withdraw	29	8	11.6%	3.2%
5.1 Use obstacles		2		0.8
5.2 Artillery		1		0.4
5.3 Routes		16		6.4
5.4 Scouts Withdrawal		2		0.8
6. Forward Movement	26	12	10.4%	4.8%
6.1 Routes		6		2.4
6.1.1 Checkpoints		4		1.6
6.2 Resources		4		1.6
7. Estimate Friendly Defense	75	42	30.0%	16.8%
7.1 Use Terrain		8		3.2
7.2 Use Obstacles		10		4.0
7.3 Use Engineer		14		5.6
7.3.1 Protect Engineers		1		0.4
8. Accommodate Cmdr	4	4	1.6%	1.6%
Total	250	250	100.0%	100.0%

Decision making. There were 27 decision points identified from the transcripts of the five-hour planning session. The decisions were coded with respect to whether or not they represented Recognition-Primed Decisions (RPDs). Klein (in press) has distinguished between recognitional and analytical decisions. Recognitional decisions, also termed RPDs, occur when a decision maker recognizes a situation as typical, recognizes the typical reaction to that situation, evaluates the reaction for feasibility, and then either implements it, improves it, or rejects it for another reaction. "Typical" in this context is used to refer to a situation that the decision maker has previously experienced or has been taught to expect or anticipate. In contrast, analytical decisions involve the generation of a set of options that are compared to each other on a set of evaluation dimensions. This strategy is based on concurrent deliberation of options. We coded our data by determining whether each decision point involved some form of concurrent deliberation of multiple options (non-RPD) or if it involved only serial examination of one option at a time (RPD).

Twenty-six of the decisions were classified as RPDs while only one was analytical. That is, of the 27 decision points observed during the five-hour exercise, only once did the planners contrast two or more options. The classical laboratory decision model has generally examined concurrent decisions based upon novel domains. It is fairly evident that in this particular planning exercise, there was little applicability of classical models (for example, see Slovic, Fischoff, & Lichtenstein, 1977) since, for these personnel working within a familiar domain, serial or recognitional processes accounted for 96% of the decisions.

Table 6 describes the 27 decisions as well as indicating the reference unit location and approximate chronological placement in the planning process.

Table 6

Decision Point Descriptions

Decision Point Number	Reference Unit Location	Approximate Chronological Location	Decision Point Description
1	2	3 min	Place guard to see bridge blown
2	3	4 min	Put observation forward
3	7	9 min	Assign priority of efforts
4	24	30 min	Everyone clear out of room
5	28	35 min	Block this road
6	40	50 min	Select unit battle position
7	47	59 min	Engineers to proceed with plan
8	48	60 min	Dig tank positions here
9	54	68 min	Leave scout to guard bridge
10	56	70 min	Get 12 hours setup prep time
11	61	76 min	Move the units on this route
12	61	76 min	Place the RP here
13	91	121 min	Do not use checkpoints
14	99	124 min	Make this the engagement area
15	104	130 min	Request two dozers
16	108	135 min	Blow these three bridges
17	108	135 min	Assign battle positions and EAs
18	108	135 min	Put battle positions along RR
19	108	135 min	Send dozers north and work down
20	112	140 min	Put decon sites in this area
21	157	196 min	Crater road and FASCAM clearing
22	184	230 min	Have BP fire into this EA
*23	192	240 min	Recon to identify enemy route
24	195	244 min	Seal woods with scout and abatis
25	211	264 min	Place B, C, & D Companies here
26	220	275 min	Dig four battle positions here
27	220	275 min	Put wire here to make them turn

*This is the only decision where multiple options were considered.

Option generation. The transcripts were coded to identify the generation of options throughout the planning session. A total of 102 options were identified. The majority of these were simply mentioned during the planning session and were not analyzed during any of the 27 decision points discussed above. These options were divided into three categories:

- Those that the researchers could, with confidence, say were incorporated into the final working plan (n=45),
- Those that either were not used or those that the researchers were not certain of having being included in the final plan (n=50),
- Those that were Commander's options and not actually generated by the planners (n=7).

Since it is generally assumed that a decision is necessary to "select" an option, an attempt was made to match the 27 decisions to the 45 options that we felt confident did appear in the final plan. The result was that 20 (44%) of the options could be traced to specific acts that could be considered as decisions while 25 (56%) appear to have become part of the plan without any overt decision making. Possibly the officer in charge of operations made these decisions without requiring group discussion so they did not show on our transcripts. Another possibility is that some of these were "accidental decisions," i.e., these options became part of the plan without anyone consciously making the decision.

Information seeking and acquisition. There were 164 discrete pieces of information brought to the attention of the planners that we could identify from the five hours of transcripts. The manner in which this information was obtained was classified as either "active" or "passive". The active category included any information that was requested while the passive category referred to information that was not requested such as material volunteered by other individuals or that was available within the planning environment. Sixty-nine percent (n=113) of the information acquisition was passive and thirty-one percent (n=51) was active.

The 164 pieces of information were also coded as to the nature of their source. Seven sources were identified as follows: individuals, the current state of the plan, the map, the operations order, the commander, brigade, and Soviet doctrine. The operational definitions used by the coders for these sources with examples are as follows:

Individuals: People who were physically in the planning room who possessed the information and passed it on either voluntarily or upon a request. This could also include information passed from subordinate units to planners prior to their coming into the planning area under observation. For example, from an individual's personal experience in the area, he said: "These roads are not going to be marshy."

The Plan: Information available to the planners by virtue of the current state of the plan. This generally is the information the planners added to the map overlays. This is not to be confused with the basic information available from the map itself. For example, a player said while examining the plan overlay of the map: "Not good. [There is] nothing to keep the enemy in there...no obstacles."

The Map: Information which is inherently available to the planners from the map of the area of concern. This information generally involved terrain features, routes, natural obstacles and barriers, etc. This should not be confused with aspects of planning generated by the planners that would be found on the map overlay. For example: "There are four bridges in this area."

The Operations Order (OPORDER): Information that is available to the planners from the orders they have received about the operation they are planning. This would involve material such as the current location of friendly units, sector boundaries, or other friendly units in neighboring sectors. For example: "We have two days to set up."

The Commander: Information that is spelled out by the Commander in his intent statement. For example: "Delta Company goes here."

Brigade: Information that is acquired from brigade headquarters (the next HQ level above the individuals in this exercise). For example; after contacting brigade a player said: "There was no nuclear release."

Soviet Doctrine: Information that is cited from the materials and handbooks about Soviet Doctrine. For example: "The [enemy] will come down the major roads...this one or this one."

Table 7 shows the frequencies and percentages of these sources of acquisition of information by active, passive and total categories.

Table 7

Sources of Acquisition of Information

Source of Information	Active		Passive		Total	
	Number	Percent	Number	Percent	Number	Percent
Individuals	19	37.3%	50	44.2%	69	42.1%
Plan	17	33.3	8	7.1	25	15.2
Map	6	11.8	52	46.0	58	35.4
Op Orders	5	9.8	1	0.9	6	3.7
Commander	2	3.9	1	0.9	3	1.8
Brigade	2	3.9	0	0.0	2	1.2
Soviet Doctrine	0	0.0	1	0.9	1	0.6
Totals	51	100.0%	113	100.0%	164	100.0%

More than two-thirds of the information was passively acquired, with over 92% of it being from extremely accessible sources such as individuals in the room or the map. The actively acquired information constituted one-third of the total information, with 70% of it also being from very accessible sources (individuals or the current plan). The battalion intelligence (S2) section as a source of information is glaringly missing. There was no one from the S2 section present in the S3 section during this time and the S3 section did not solicit any information from the S2 section. In general, if the information was not immediately available it was not acquired.

Nature of transitions between segments. The nature of the transitions between the objective segments was examined. Eleven types of breaks were identified. They are as follow:

In-Context Appraisals (ICA): Transitions which occur because discussions which are in the context of the current focus redirect the planners onto a new focus. For example, the planners were discussing friendly strategy when the observation, "I've got to cover the whole sector cause I don't know where [the enemy] is going to come. These fallback positions [aren't very good]..." redirected the objective to the engineering efforts necessary to improve the fallback positions.

In-Context Questions (ICQ): Transitions which occur because a question which is in the context of the current focus redirects the planners onto a new focus. For example, the planners were discussing friendly strategy about the use of artillery and mine placements when the question "What do we have for engineering assets, how much mines have we used and what have we got now?" redirected the objective to engineering assets and efforts.

Out-Of-Context Appraisal (OCA): Transitions which occur because discussions which are out of the context of the current focus redirect the planners onto a new focus. For example, the planners were discussing engineering efforts when the observation "I've got an order to put out at 1300" redirected the objective to plan "housekeeping" issues.

Out-Of-Context Questions (OCQ): Transitions which occur because a question which is out of the context of the current focus redirects the planners onto a new focus. For example, the planners were discussing what the commander would accept as a suitable obstacle plan when the question "Where do you want my company to be?" redirected the objective to routes and position issues.

New Information (NI): Transitions which occur because new information that is introduced to the planners redirects their focus. For example, the planners were discussing obstacle and engineering issues when the new information "I might be able to get you a chemical release" was presented which redirected the objective to artillery issues.

Old Information (OI): Transitions which occur because old information that is reintroduced to the planners redirects their focus.

Natural Resolution (NR): Transitions which occur because an issue has been taken as close to completion as is possible at a particular time in the planning process and therefore a natural transition is made to another focus. A decision could very likely lead to a natural resolution. For example, the planners were discussing routes and positions when they resolved the issue ("If you think [these roads] will be good then I'll just use this one right here.") and then proceeded to a friendly strategy objective.

Return to Previous Context (RP): A transition which occurs as a result of an individual intentionally redirecting the planning group to the focus of a previously addressed issue. For example, the planners were discussing obstacles, when an out-of-context question redirected them to friendly strategy. Shortly thereafter, the S3 tells the distracted individuals to "... look on those overlays. Checkpoint 60 on the route..." and then redirects the discussion back to obstacles with "What I'm doing now, I'm trying to figure out where to put obstacles..."

Time Break or Change of Circumstances (XXX): A transition which is the result of a break in action, taping, etc., e.g., a break for lunch.

Forced Change (FC): Any transition which occurred because an individual abruptly forced the planning focus to another area. This resulted when someone of "rank" redirected the planning, for instance, for a briefing. For example, the planners were discussing routes and positions when the commander appeared and asked "Where is my main defense area now?" which redirected the objective to friendly strategy.

Option Generation (OG): A transition which occurred as a result of an in-context generation of a new option which redirected the planning to another focus. For example, the planners were discussing artillery support to help blow bridges when the option "Options sheet, don't blow all the bridges" was generated which redirected the objective to a discussion of the use of obstacles.

Table 8 shows the frequencies and relative percentages for these eleven categories of transitions between objective segments.

Out-of-context questions and out-of-context appraisals accounted for nearly one-third of all transitions while in-context appraisals and questions accounted for 20 percent. The category of Old Information was initially hypothesized as being a potential reason for transitions to take place, however, it was not responsible for any. Only eight percent of the transitions were the result of natural resolutions (some of which were decisions).

Table 8

Nature and Frequencies of Transitions

Nature of Transition	Frequency	Percent
Out-of-Context Questions	19	29.7%
In-Context Appraisal	12	18.8
Time Break or Change of Circumstance	7	10.9
New Information	6	9.4
Natural Resolution	5	7.8
Return to Previous Context	5	7.8
Forced Change	5	7.8
In-Context Questions	2	3.1
Out-of-Context Appraisal	2	3.1
Option Generation	1	1.6
Old Information	0	0.0
Total	64	100.0%

One implication of this finding is that in a group decision environment such as this one there is a great deal of accidental shifting from one focus to another. This process is one that must be actively managed in order to keep it from becoming chaotic.

Progressive deepening. Progressive deepening is a model of deliberation by which an individual evaluates an option or idea by gradually examining deeper and deeper "branches" of the idea for workability or flaws. Eventually a point is reached where the idea is either accepted, rejected, or left hanging due to some distraction. If it is rejected, the decision maker either moves on to a totally different option or goes back up the deepening chain to a point (theoretically) above the source of the flaw and then follows another branch, once again testing its merits all along the way.

The deliberation processes of four separate segments of planning discussions were charted to see if the Army planners demonstrated progressive deepening. The charts for these four segments are included in Figures 1, 2, 3, and 4. The respective transcripts which correspond to the charts are included as supplements to each figure. Table 9 which follows Figure 1, is a narrative description of the steps contained in that chart and is intended to give an example of how to read the charts.

The first three diagrams are charts of the continuing deepening of the same topic through three noncontiguous segments of the planning process. The first and second segment were separated by approximately 30-45 minutes, while the second and third were separated by an additional two and a half hours.

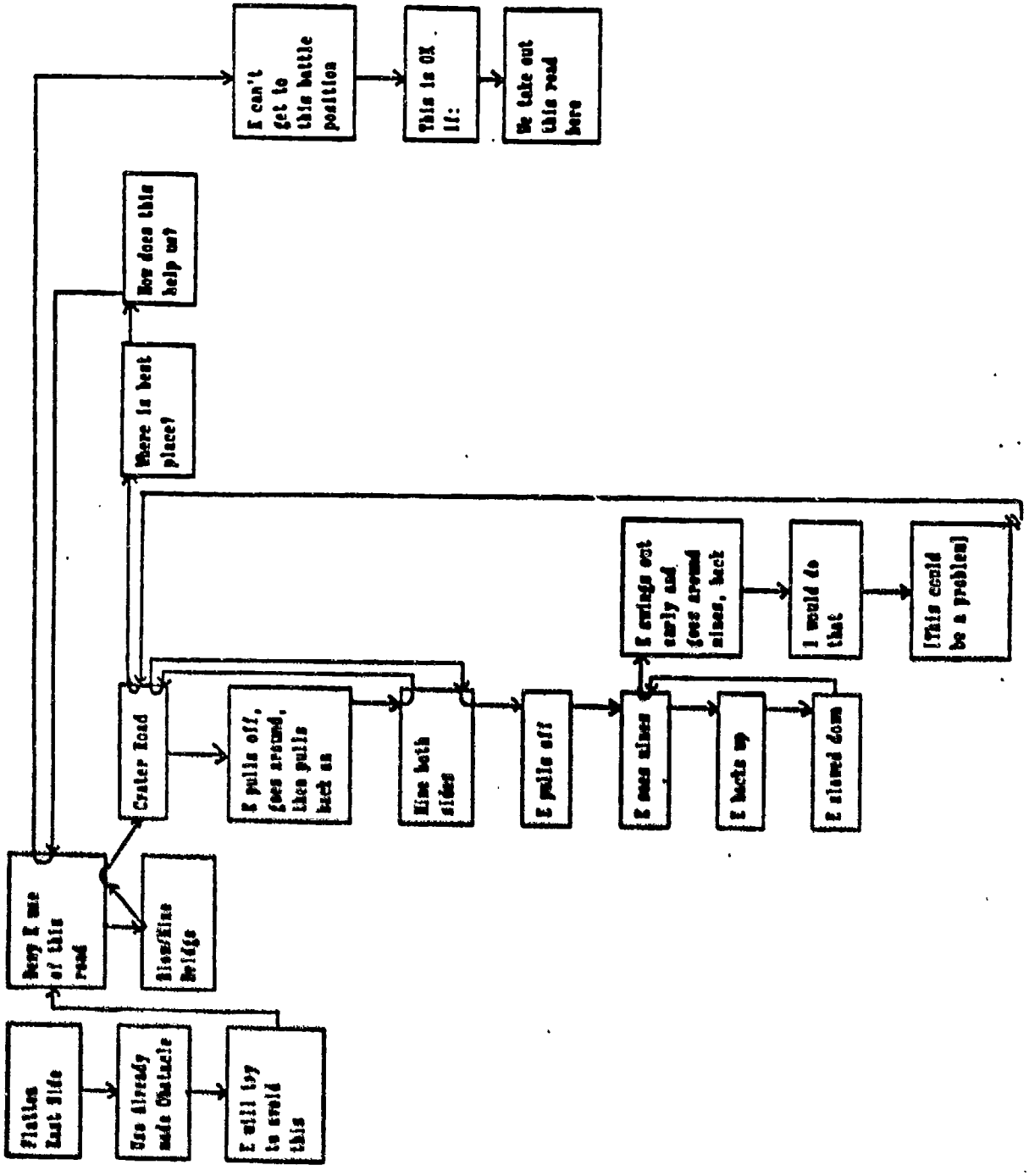

Figure 1. Progressive deepening diagram for unit #25.

SUPPLEMENT 1
TRANSCRIPT ACCOMPANYING FIGURE 1
REFERENCE UNIT #25
Approx. 30 min. into planning session.

X: I think that's a great idea, why not use an already made obstacle. They would try to avoid this, this is where we need to stop them from using, stop them from using that road right there. Only way to stop them is to blow this mine here, that bridge there. See if you crater that road all they do is they just pull off the road go in the woods and come back on the road. That might work, I'd say that would be a good idea there. Mines on both sides. Well, ok, so we crater it, we put mines on both sides, so they pull off the road cause they can't use it, they see mines, so they're backing up, that's going to slow them way down, if they see the mines in time what's keeping them from just swinging out and just getting back on the road, that's what I would do, that's the only thing. Which would be a better place to crater it? What's that do for us, how does that help us.

Table 9 is a narrative description of Figure 1 and is included as an example of how the figures are to be interpreted.

Table 9

Narrative Description of Progressive Deepening, Figure 1

Step	Step Explanation
1.	The planner examines the map and notes that they need to flatten the east side of the railroad track and observes that...
2.	By doing this they will make use of an already made obstacle...
3.	This will cause the enemy to try to avoid it.
4.	The planner looks further eastward on the map. He then notes that they will need to deny the enemy the use of "this" particular road...
5.	One way to help accomplish this is to blow or mine a particular bridge...
6.	The enemy can also be denied the use of "this" road by...
7.	Cratering the road...
8.	But the enemy will just pull off the road, go around the craters, pull back on and continue...
9.	We could mine <u>both</u> sides of the road...
10.	We could crater the road <u>and</u> mine both sides, then...
11.	The enemy will pull off because of the craters...
12.	They will see the mines...
13.	They will have to back up, resulting in...
14.	The enemy being slowed down.
15.	But what if the enemy sees the mines in time...
16.	He will swing out early and go around the mines as well and then get back on the road and continue...
17.	The planner indicates that he would do it that way.
18.	This problem causes a brief pause.
19.	If we crater the roads...
20.	Where is the best place?...
21.	How will cratering the roads help us?...
22.	It will deny the enemy the use of the road, therefore...
23.	The enemy won't be able to get through to "this" battle position.
24.	This will be O.K. if we take the road out here.

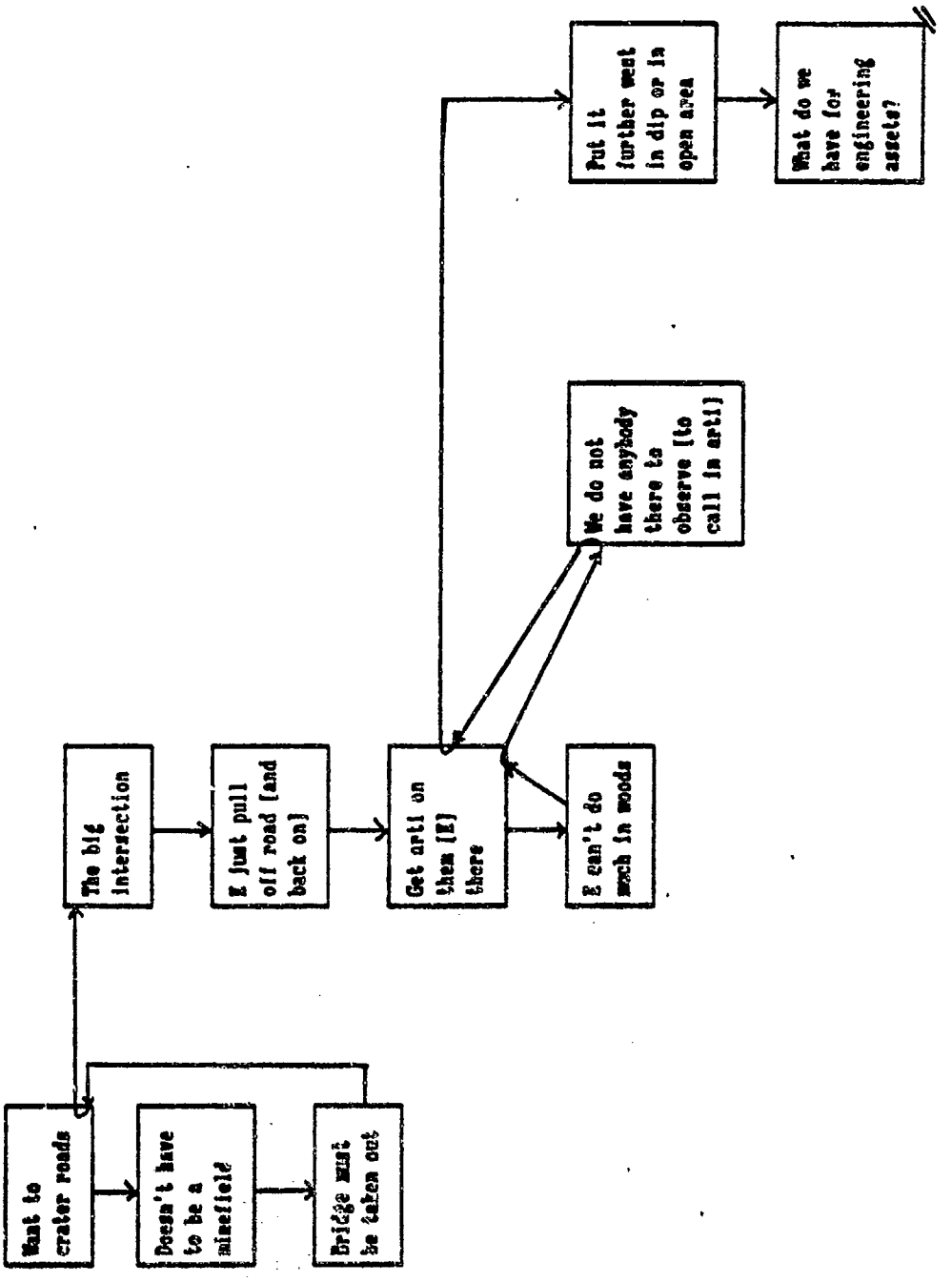

Figure 2. Progressive deepening diagram for units #44, #45 and #46.

SUPPLEMENT 2
TRANSCRIPT ACCOMPANYING FIGURE 2
REFERENCE UNITS # 45-48
Approx. 45-60 minutes into planning session

Y: What I want is a crater, it doesn't have to be a mine field, I just want a crater, I'm just putting a symbol there to show that there's some demolitions there. I guess I could just go with the X, which is what I was told. Naw, just as long as the bridge is taken out, that's what I want done.

Z: Bob, why don't you do that intersections up there?

Y: What's that?

Z: On phase line Idaho, up in the north, that big intersection, crater that mother.

Y: What will that make them do other than pull off the road?

Z: We're going to get artillery on them in there, cause they're not going to be able to do very much in the woods, but nobody can observe the artillery there though.

Y: I see what you're saying, we thought about that one, but...

Z: or place if further to the west down in the dip or in that open area somewhere. What do we have engineer for assets, how much mines have we used and what we've got now?

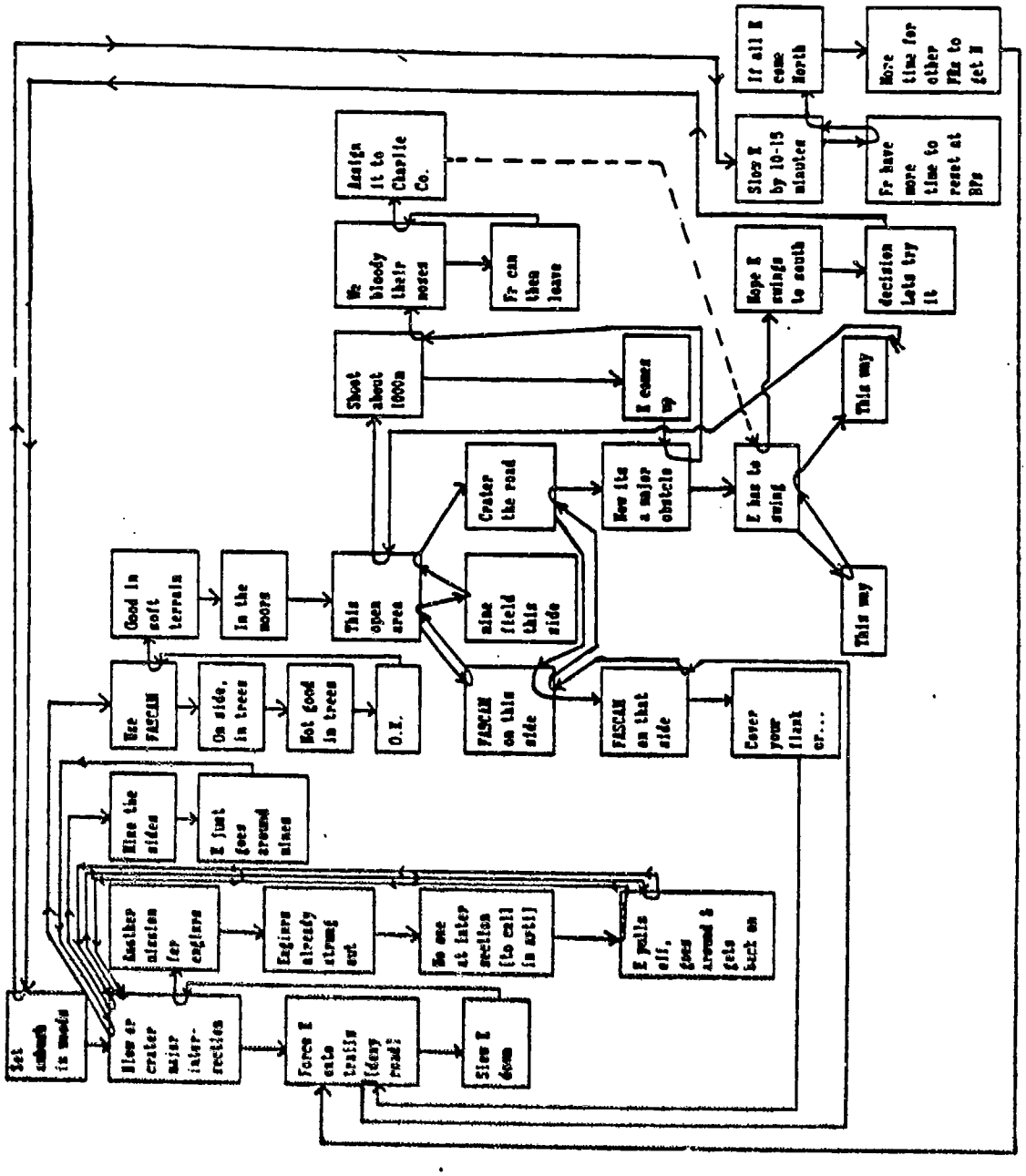

Figure 3. Progressive deepening diagram for units #148-158.

SUPPLEMENT 3
TRANSCRIPT ACCOMPANYING FIGURE 3
REFERENCE UNITS 148-158
Approx. 2-1/2 to 3 hours into Planning Session

W: yeah, that's what we were talking set up ambushes in the woods and stuff, then thought about blowing like some of those major road intersections, like if he does come through here at least force them into the trails to slow them down.

Y: We thought about, we talked about it, the reason I didn't put anything is that's another mission for engineers that are already strung out, and realistically with no one there, if I did blow them all they would do is pull off the road, get back on it and just keep on trucking. Ok, we crater that intersection, they come to it, they get off the road go around it, and get right back on again.

W: Mine the sides.

Y: They'll just go around the mines. Ok, how about a spot for a FASCAM then, would that make sense, how about either side of the roads, in the trees.

Z: Trees are not good.

Y: No, ok.

W: See the whole purpose of doing that is so they don't catch the redball and here again you're displacing you don't get into a road rally.

Z: Soft terrain is best, yeah, I can throw it in the trees.

Y: Ok, then how about in the moors, we got an open area, how about a FASCAM on this side, maybe a mine field on this side then, crater the road, would that be a good spot then? Ideally would be maybe a FASCAM here and a FASCAM on that side.

Z: Cover your flank or...

Y: What we're trying to do is to deny them this road if they decide to use it. If we drop a FASCAM here and here and crater the road that's a major obstacle now, now they have to swing away, either down this way or way up this way if we do that.

W: Right in there, there's enough of a clearing to put about a 1000 meters, they run up to the crater and start playing around in the FASCAM, you bloody their nose, you now know that they are there, and then he gets out.

Y: Ok, I give that to charlie then.

X: All we need is a squad and then hope that anybody filing out will try to go down to the south.

Y: Ok, lets' try that and see how that works.

X: Looks like ambush all day and if it slows them down 10 or 15 min it gives you that much more time back here to reset. If they're all coming to the north it will give delta some more time to push up to the north.

Y: Sound great I like that, that's what we need to do. Just don't give them the road, that's why I was trying to mine these here.

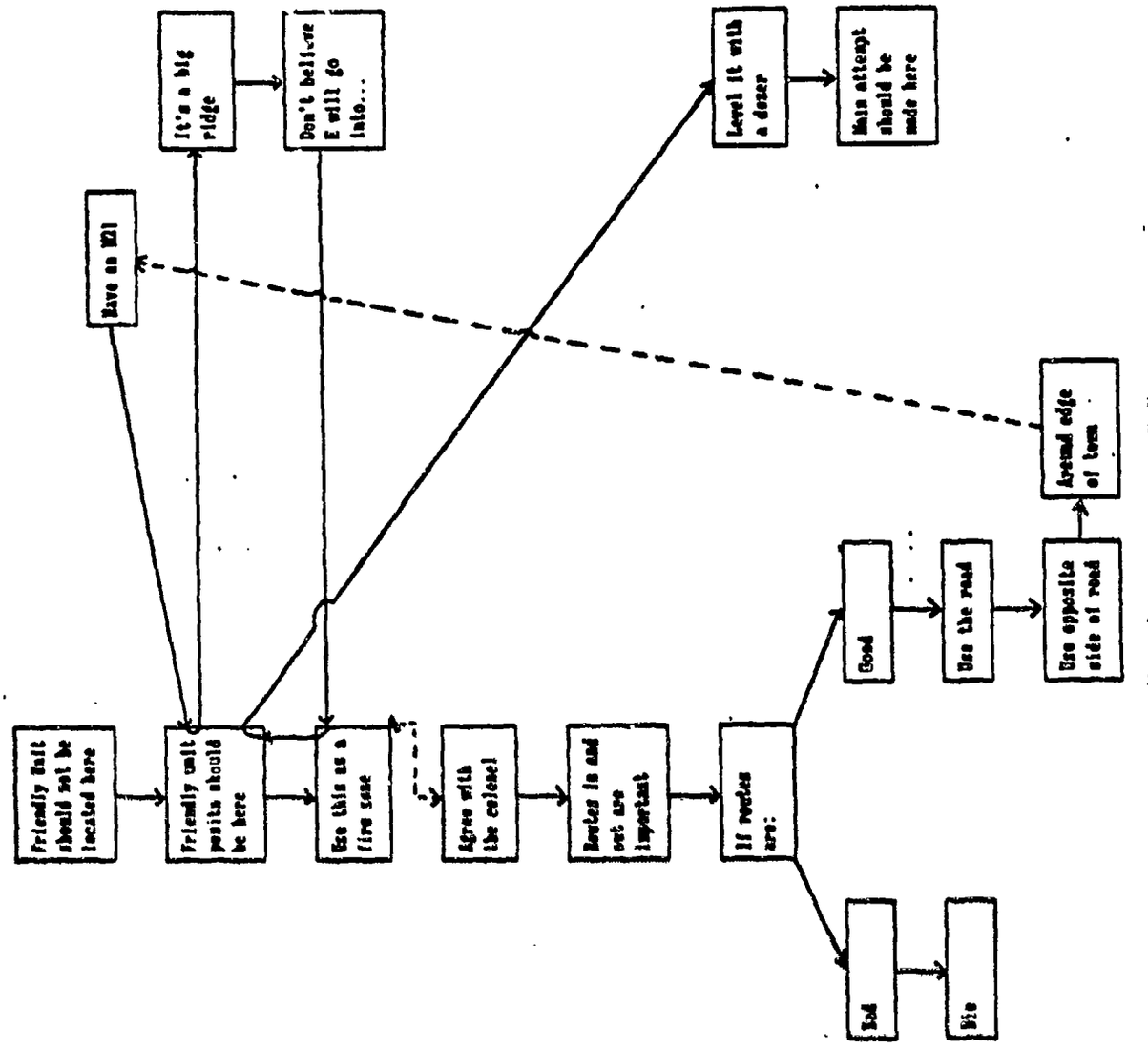

Figure 4. Progressive deepening diagram for unit #26.

SUPPLEMENT 4
TRANSCRIPT ACCOMPANYING FIGURE 4
REFERENCE SECTION # 26
Approx. 35 min. into planning session.

X: It keeps them from using that road to come down on this battle position I agree with that, if you take it out here. Ok, I'd say rather than sitting in here I think they should be up here, use this fire zone here. I guess I basically agree with what the Col. said, if it works right, cause the thing that is important in this is routes in and out of these positions, if you don't have them, then you die with that. Let's use the road, why not, use the opposite side of the road, around the edge of the town. Ok, so I've got an M21, do I want to put them there, why am I putting them there? Yes, it's kind of a big ridge is what it is, I just can't see them going into here. We want then to go into there but will they go into there. I agree with these positions, these make sense because you take that dozer and just level that out. I think this is where our main attempt should be right in there.

The diagrams indicate that progressive deepening was taking place. The planners worked their way down branches, evaluated as they went, occasionally jumped back up to earlier nodes and them branched off in slightly different directions. A variation on this pattern took place when a break in time was involved and the planners returned to a partially deepened topic that had been addressed earlier. In these cases they generally started on a higher node than where they previously left off and sometimes jumped around through branches already covered. Eventually though, they settled down to a more consistent deepening pattern and took it to a point farther along than they had previously reached.

The concept of progressive deepening was introduced by de Groot (1978) in his protocol analysis of chess grandmasters. It is a very effective strategy for pursuing the implications of an option. It is contrasted to a broad-based search whereby a large number of options are scanned to a shallow depth. By relying on progressive deepening, the battle managers were using a sophisticated strategy that placed additional demands on them because it requires the ability to recall the way the line of reasoning was developed, and to judge the best lines for continued evaluation.

By its very nature, progressive deepening's free-flowing, informal reasoning allow the group decision processes to be accidently sidetracked. However, we have also seen that with the use of a structuring aid, such as a synchronization matrix, this shifting of focus is minimized.

Assessment of CDM

CDM applications in military settings. CDM can be effectively used in a military setting. The Ft. Hood exercise demonstrated that the method could be applied in dynamic battalion pre-battle planning.

CDM originally was designed as a post-event interview to assist researchers in extracting information from participants about their decision-making processes. It has been demonstrated to be flexible enough to work at least as well, if not better, in situations where the researchers are present during the event. In these circumstances, the interviewers generally take notes, observe, and, when there are breaks in the action, interview key participants. This latter variation of CDM is the method employed during the Ft. Leavenworth and Ft. Riley data collection trips. Another iteration of the method was demonstrated during the Ft. Hood exercise using adjunct data (from audio tapes) to substitute for many of the CDM probes and potentially allowing a more effective set of probes. In this case, the planners were involved in group decision making involving large amounts of verbal communication at a central location. During the course of the interviewing for this particular exercise it became evident that answers to the interview questions were already available in the content of the discussions taking place in real-time. That is, we appeared to be wasting time asking the S3 about which options he considered at a given decision point, since the answer was clear from the discussion we had taped. So, even though the participants were very cooperative with the interviewers, the process was deemed to be redundant. The answers to CDM probes were extracted from the real-time transcripts. This method tended to preclude the problem of participant recall which arises with any post-interview method.

The results indicate that variations of CDM can be applied in quite diverse environments including: a) non-observation with post-event interviews; b) direct observation with during-event and post-event interviews; and c) direct observation and audio taping, with data extraction applied to the real-time transcripts. Here, also, direct observation clarified missing visual information.

Modeling group decision making. CDM has previously been applied to individual decisions. The Ft. Hood scenario allowed the researchers to track a group decision process. The nature of the planning exercise permitted this. The result was that this type of protocol analysis allowed us to "map" the entire five hours of the planning process into the categories previously discussed. The "map" itself is a fairly intimidating 22 foot long sheet of computer paper (see excerpt, Appendix C). However it allows one to conceptualize the processes taking place in order to facilitate other analyses.

Discussion and Conclusions

Applications to Natural Settings

The CDM was applied in three separate military settings. Each of these involved a command post exercise or field training exercise in which a command post staff operated on dynamic information to develop plans under near real time constraints. The last of these exercises, a computer driven battalion level exercise at Fort Hood, Texas, offered the richest source of data. It was decided to focus the decision analysis efforts entirely on these data.

Management of the Planning Process

There is a need for military planners to be trained in the management of the planning process. Military planning is generally viewed as the artful manipulation of critical elements such as strategy, intelligence, tactics, logistics, fire and air support, planning for immediate versus future battles and so on. Indeed, when military planning was chosen as the domain for this project, we were very impressed with the amount of specific domain knowledge required just to follow the planning discussions as they were taking place. However, the management of the process would appear to be as critical as the actual planning itself. Military planners are specifically trained to work with the domain specific knowledge but receive relatively little training in the management of the process.

Our analysis showed 64 major transitions between objectives of discussion during the five-hour planning session. This indicates that the planners were switching objectives about every five minutes. This does not prove that the process was managed poorly, but it does emphasize the need for management. During these 64 discussions, only one objective out of 12 (movement of friendly troops from a previous battle sector to the current one) was addressed and followed straight through, uninterrupted, to resolution.

We were surprised that 33% of the transitions were essentially "disconnects", i.e., out-of-context factors such as outside interruptions that moved the planning discussions from one topic to a totally unrelated one. Often after these transitions, the discussions never returned to the specific focus

of the earlier topic. Another important aspect of these transitions was that they often occurred without any apparent concern on the part of the planners. They did not seem to notice that they had left one topic behind and were now on a completely unrelated one.

In comparison, a little over 20% of the transitions occurred as a result of in-context factors. Once again, these transitions were often extremely subtle. The planners, starting from within the current context often completely re-directed themselves to a totally unrelated topic, without verbalizing any awareness that a transition had taken place.

In addition to transitions between topics, the development of the plan involved processing large amounts of information (164 separate pieces) and the generation and (sometimes) serial evaluation of numerous options (102). Tracking this information and these options, in addition to monitoring the topic transitions, places a real burden on the management of the process.

Group development of a plan under time pressure is beset by confusion, overloading and chaos by its very nature. This same confusion, overloading and chaos makes managing the process that much more important and difficult. It is hard to manage the planning discussion while you are participating in it.

We will expand on these ideas in following sections and present recommendations for training and decision support systems.

Information Flow and Access

During the interviews with the planners, one point was consistently discussed -- the need for more and better information. Although many types of information were mentioned, the one that was touched upon by everyone was for more complete and accurate enemy intelligence. Other popular topics were the need for planners to actively seek out the information they lacked, to keep track of this information and to know when to apply it.

There were two main points of contradiction between the interview comments and the planners' actual performance as observed. The first was that intelligence about enemy actions was repeatedly identified as a primary need yet the S3 planners never used S2 (Intelligence) as a primary source of information. There were seven main sources of information identified during the five hours of planning (see Table 8). These ranged from individuals present in the planning room to the Commander and the brigade headquarters. S2 was not one of these sources.

The failure to use the S2 may have been the result of the second contradiction that we observed: the planners did not actively seek information they needed. If the material was not in the immediate area (i.e., in the planning room) and easily accessed, they did not go looking for it. In fact, 93% of the information was from three sources which were right there with the planners; individuals, the map, and the plan (overlays, etc.). The remaining seven percent was from the four sources which were not as easily accessed: the commander, brigade headquarters, the operations order, and Soviet doctrine materials. Indeed, when the operations order and Soviet doctrine were sources of information it was because someone in the immediate area happened to be able to

recall the information from memory, i.e., they did not go "look it up." The last update from the S2 was approximately two to three hours prior to the analyzed five hour planning segment. Following this briefing, the S2 worked exclusively in his own section and no one in the S3 section solicited update information from the S2. The S2 vehicle was only about 25 feet from the primary S3 planning area but they were not in direct line-of-sight, thus making the S2 area somewhat less accessible to the S3 section.

Another interesting point concerns passively acquired versus actively acquired information. Passively acquired information outweighed actively acquired information by greater than 2 to 1. Of the actively acquired information, we found that most of it was still from the same three immediately accessible sources (82%). We were surprised at this result primarily because the planners' comments in the interviews led us to expect that they had more actively attempted to acquire whatever information was needed.

In summary, the planners did not use information from S2 even though they repeatedly stated that they needed more enemy intelligence. Also, if the information was not very easily accessible, (i.e., in the room) they more than likely did not track it down.

The implication is that information may not flow unless it is already close at hand. This highlights the need for decision aids and support systems that will help make information very easily accessible. Training is needed to increase the awareness as to the necessity for more active retrieval of these materials.

Decision-Making Strategies

The classical, prescriptive models of decision making typically indicate that decisions should be made through a deliberate process where as much information as possible is compiled about available options. These options are then deliberated concurrently and a final decision is made based upon a multi-attribute weighting which allows a determination of the strongest alternative. This becomes the chosen option. In fact, Army doctrine is consistent with prescriptive decision models suggesting military planners should generate a set of options and select the best. The main question that arises is whether or not this concurrent deliberation model is relevant to natural decision making situations.

We have shown (Klein, Calderwood, & Clinton-Cirocco, 1986; Klein, in press) that "experts" in natural decision-making settings operating under various levels of time pressure and stress do not follow the classical decision process. These individuals have been shown to approach the decision-making process by addressing one single option at a time. Often this involves making an automatic decision, with little if any deliberation. When multiple option deliberation does occurs, it tends to be along serial, rather than concurrent, lines. In this case the decision maker considers one option at a time and either accepts it as a workable solution, or rejects it and then moves on to a completely different option and repeats the process. These decisions, involving automatic and/or serial consideration of options have been labeled Recognition-Primed Decisions (RPDs).

As mentioned, in our previous studies involving individual decisions with experienced individuals working in familiar domains, the majority of the decisions were RPDs. This study differed in that it was a group decision setting with a broad mix of levels and types of experience and expertise. However, we found 96 percent of the identified decisions (26 out of 27) were RPDs where there was no concurrent deliberation. That is, multi-attribute weighting of options, decision analysis and/or Bayesian strategies did not come into play. This represents an even higher percentage of RPDs in this group decision setting than in previously studied individual decision-making settings.

The planners we studied consistently used RPD, serial decision strategies, much like other experienced decision makers we have observed. This involved finding options that could potentially satisfy the requirements of the situation and "playing out" the option in their minds or on a map through progressive deepening. These individuals did not concurrently deliberate options even though Army doctrinal writings suggest it should be done.

Military decision training has traditionally been based upon Multi Attribute Utility (MAU) analysis, decision analysis, or Bayesian approaches. These approaches are inconsistent with the decision strategies that are being employed by these military planners (or any other job incumbent we have observed). If one accepts the assumption that experts are deemed such because they generally make correct and timely decisions, then a logical approach to training might be to capture the salient aspects of their decision strategies by knowledge elicitation and then to convey these same strategies to individuals with less expertise. The results reported in this paper suggest that the traditional training of MAU, Bayesian and Decision Analysis techniques is an unnatural approach. As such, it could potentially interfere with the learning process and reduce the credibility of the training, resulting in an inefficient use of valuable training time.

Evolution of Method of Data Collection and Analysis

Initial projects involved conducting CDM interviews after the fact (Klein, Calderwood, & Clinton-Cirocco, 1986). In these cases the participants would reconstruct an important event and identify critical points. The researchers would then interview the individuals about the critical decisions and cues.

A later variation of the CDM allowed the researchers to be on site during the course of the major events (Taynor, Klein, & Thordsen, 1987; Brezovic, Klein, & Thordsen, 1987). This permitted the researchers to conduct the interviews with the participants either afterwards or during breaks in the incident. The researchers were able to use direct observation and their notes of the event to verify aspects of the recall of the interviewees.

These two early approaches were very effective in providing data concerning critical decisions and the cues attended to by the decision makers. This included much detailed information about the decisions such as deliberation strategies, time pressure and options. These approaches were very effective in capturing the occurrences directly preceding, during and immediately following decisions. They did not attempt, however, to capture the intervals between decisions.

The data collection approach initially envisioned for this study was to examine the military planning process from two perspectives simultaneously: S3 (Planning) and S2 (Intelligence). Two researchers were to observe (one in each section) the development of a military plan. Critical incidents and time frames were to be used as anchors for focusing the CDM interviews. In the observation at Ft. Leavenworth, Ft. Riley and the initial periods at Ft. Hood this approach was followed.

During the course of the initial interviews at Ft. Hood the observers noted that the responses often covered the same ground the planners had just openly discussed in the actual planning session. Based upon this discovery, it was decided to audio tape record the actual planning session itself and to use the interviews to address material which could not be picked up from the planning discussions. The resulting transcribed data were based directly upon the actual event and did not need to rely on the participants' and researchers' recall. The data could then be analyzed by mapping the development of the plan and in essence extracting many of the interview "responses" directly from the transcripts.

This application of CDM resulted in a data analysis that was primarily driven by the progressive deepening model of decision making (based on the entire flow of the planning process). This process generated an extremely rich data set. However, there were several weaknesses in this approach. The first was that less effort was given to analyzing the CDM interviews than to analyzing the transcripts of the planning session. The second weakness was that we used our usual format for the CDM interviews rather than shifting focus to use a more valuable set of probes (e.g., probes getting specifically at training issues). It was only afterwards when we reviewed the transcripts that we realized that the CDM interviews were redundant with the tape recordings. A third weakness was that the transcripts did not reveal some subtle aspects of decision strategies and situation assessment, aspects that could have been elicited by the CDM if it had been properly coordinated with the transcript data.

We used several different methods for the final analysis of the data for this project. The first was a systematic mapping of the content analysis (Appendix C). This mapping allowed us to systematically track the process as it deepened and as it jumped around during the transitions. The second method involved extracting the timing and frequency or various types of planning activities directly from the transcripts. The third method was the development of the progressive deepening charts. This is an approach to protocol analysis we have not seen used before, where the charts were developed directly from the transcripts of complex, real world events. De Groot (1978) and Newell and Simon (1972) have obtained such data from artificial protocol gathering "think aloud" studies. However, because we were recording a group decision-making session we could be less intrusive. Finally, the fourth method employed was the original CDM.

All four of these analysis methods were beneficial in helping to understand the group decision processes. However, it is best to consider the first three as separate tools to be applied alongside the CDM. Extracting information after-the-fact from the transcripts provided some of the information normally gained by the CDM interviews. At the same time strict cognitive processing was

not captured by this method. That is, we were able to identify options generated, the overall manner in which deliberation took place (serial versus concurrent), the amount of time of deliberation, available information, some critical cues, decision points, types of RPDs, etc. However, certain material normally gained from the direct CDM interviews was not captured by the other methods. This included much of the data from the "higher order" probes such as: How would the individuals have handled a situation at an earlier, less experienced period in their lives? What decisions were considered "critical decisions" by the individual? Why were these decisions considered critical? What were the specific critical cues attended to by the individual? In future studies we would reserve the CDM interviews for these types of probes and collect the decision strategy data from the tapes. We feel that combining the use of these methods would be a good way to strengthen the process of studying complex situations.

Implications for Decision Support Systems and Decision Aids

As mentioned above, MAU, Decision Analysis and Baysian approaches were generally not being used by the planners during the planning. If these planners are typical of current and future Army planners, we question whether it is appropriate or beneficial in this environment to use any of these approaches as the foundations for decision support systems (DSS) and aids.

The results do indicate some key factors which would be helpful to incorporate in a DSS. These include information access, option formulation, and memory and recall aids for progressively deepened parts of the plan. However, these suggestions emerge primarily from a recognitional model of decision making, as applied to our data. The CDM and the content-analytical approach used with the transcripts directly generated few recommendations about decision support systems, and we do not see them being particularly valuable for such purposes.

Information access. Information access concerns the ease of retrieval of information which is available to the planners. The results indicated that of the sources of information "tapped" by the planners, three could be classified as extremely accessible (individuals, the plan, and the map), two were moderately accessible (operations orders and Soviet doctrine) two others were less accessible (the Commander and brigade headquarters). Of these sources, the three extremely accessible ones accounted for 92.7 percent of the information. The moderately accessible sources accounted for 4.3 percent and the less accessible sources for 3 percent. If the information was not easily accessed, it quite likely was not acquired. This point is strengthened when it is noted that Intelligence, Logistics, Air Support, and Fire Support were never specifically used as sources of information. Access to this information was not extremely difficult by normal standards; a radio call or a 20 meter walk across the "compound" would have put the planners in direct contact with these sections. However, in contrast to the individual, map, and plan sources these were relatively unaccessible, and were therefore not drawn upon.

Designers have been working on concepts to present information in more or less detail for many years now. Our observations have underscored the need for such efforts. We saw many cases where needed key terrain features such as bridge locations would not be discovered until late in the planning. We would encourage this line of research to continue.

An interactive local area network tied into the Planning, Intelligence, Fire Support, and Logistics section could provide easy access to all about the current status of different parts of the plan. If this includes a bi-directional, non-intrusive "reminding" function which informs S3 of changes made by the other shops and tells the other shops which parts of their plan S3 has "checked out," it could also serve to increase and enhance communications.

Due to the often confusing, chaotic nature of planning, information must be extremely accessible to battle managers, otherwise they do not bother to acquire it.

Option formulation. During the Ft. Hood exercise, 164 discrete pieces of information were mentioned and 225 instances of appraisal activity were recorded in which 102 identifiable options were generated. These options occasionally dealt with overall course of action (COA) issues, but in general, focused on sub-decisions concerning a given COA. Many of these options were quickly discussed and then rejected, however an equal number were retained if not for immediate incorporation into the plan, at least for further discussion. Keeping track of these options is a very formidable task for the planners. The options often suffer the fate of being lost due to the distractions and the non-linear nature of the planning process. If a viable option is generated, only to be forgotten due to a change of focus of the planning topic, it may never be retrieved later. If it is retrieved, it may be only through a complete reconstruction of the earlier discussions at the expense of time and efficiency.

Could a DSS be used to help track these generated options? It was observed that the planners generally focus the planning task along two lines. First, they concentrate upon specific topics of discussion (obstacles, avenues of advance and approach, positions, etc.). Second, they usually limited their focus to portions of the battle sector that generally were defined by the terrain and existing obstacles (rivers, cities, etc.). The result is that the plan tended to develop by topic within specific geographical sub-sectors of the battle area. For example, the planners would develop a plan for the placement of obstacles along the high speed avenue of approach within the area marked "A" on the map in Figure 6. They did not plan for the placement of obstacles within the entire battle sector (the entire area of the map) all at once.

This provides us with a general model of how the planners were working with the map and their focus with respect to the tasks at hand. Building from this model we can make some recommendations for the development of the DSS. The following is a description of how one such DSS recommendation could work.

> The planners work with a digitized representation of the map of their battle sector. During the initial planning, they outline key geographical areas of their sector with a lightpen (such as section "A," "B," "C," "D," etc., of Fig. 6). These are stored as "scratch pad" areas for later reference by the computer. When the planners begin a discussion about a particular topic within a specific area of the battle sector (e.g., placement of obstacles within section "A" of Fig. 6) they use the lightpen to indicate they want to work with a scratch pad and touch this section of the map.

The planners can choose to leave this selected scratchpad area the same size, or enlarge it while they work on it. As the planners formulate an option for the placement of obstacles, they pull icons from the top of the screen and place them where they want them on the scratchpad. When they are finished they simply exit and the computer automatically saves this scratchpad under a name predetermined by the nature of the icons used (obstacles, routes, etc.). Later, when the planners return to this particular scratchpad, they will initially be shown a list of the automatically saved pads, sequentially named by the icon identifiers (e.g., obstacle1, obstacle2, mines1, FASCAM1, routes1, position1). This reminds the planners of options they formulated earlier within this specific geographical area. They can retrieve any of these previously formulated options or go back into the scratchpad to develop new alternatives. Anytime the planners desire, an option can be transferred from scratch pad status to the "real" map for inclusion in the plan.

Although this is a sophisticated mechanism, most of the supporting technology for it already exists on PC-style machines.

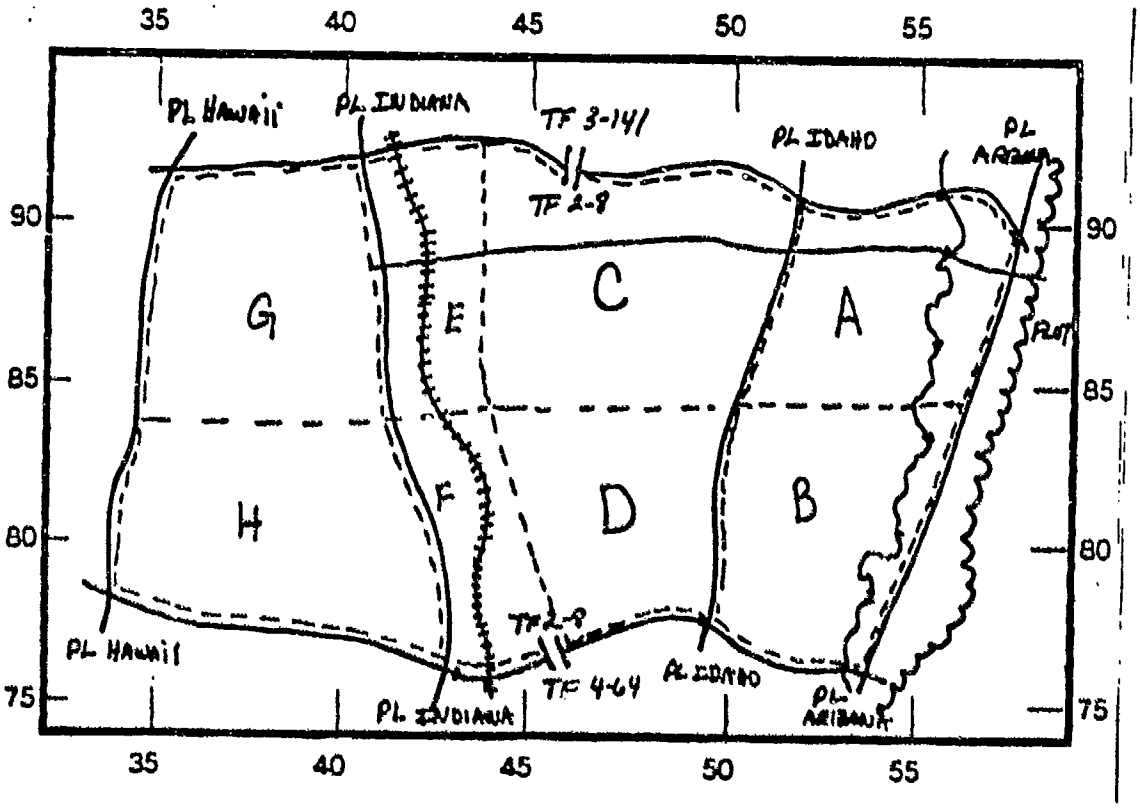

Figure 5. Option formulation map.

Memory aids for progressively deepened parts of the plan. The maps of progressive deepening chart the paths followed by the planners while they worked on particular pieces of the plan. These charts indicated that the planners needed to reconstruct "where they left off" when they returned later to the particular topic. This was not the most efficient way to "grow a plan," especially if the planners were working under time pressure. A DSS using the scratch pad mechanism discussed above could provide assistance to the planners by allowing retrieval of previously planned (deepened) segments so they can more easily reconstruct "where they left off." This could result in a more efficient use of their limited time and reduce the amount of lost information.

Implications for Training

Management activities. Battle management planning often appears confused, overloaded and chaotic. Anyone who examines the transcripts, progressive deepening sheets, and other results will be struck by how easily distracted the planners actually were. Although there is no comparative evidence that a more controlled procedure would produce better results, it seems rational to predict that reductions in repetitive behavior and concept loss would help.

This emphasizes the need for the planners to fully understand exactly how the process unfolds, including all the distractions, pitfalls, and diversions. This is especially true if we want them to be able to manage this process as well as possible. Many of the distractions were subtle and they occurred without any verbalized awareness on the part of the planners, further handicapping the person responsible for managing the planning session.

It is hypothetical whether and what kinds of training would improve process management, but we offer the following as possibilities. Training for these individuals needs to include sessions which increase their awareness of the process itself, not just their understanding of the military issues that they are to incorporate in the final product. It may be that just a couple of hours examining selected parts of transcripts, progressive deepening charts and data concerning the nature of transitions between segments of planning may be enough to increase their awareness of the potential problems. This in itself may be enough to improve performance. On the other hand, it may be necessary to also include specific training on how to actively maintain control of the process.

Modification of CDM for after-action reviews. It has been amply demonstrated that immediate feedback is beneficial to learning. It is possible that some of our analytical methods could be modified into an abbreviated format. This would be such that a domain-knowledgeable, trained observer(s) could chart the events as they occur along dimensions that would permit review either immediately following or at planned breaks during an exercise in the form of an After-Action Review (AAR). In this fashion, the planners could receive relatively rapid feedback about their actual planning style and how they direct the decision making process. Realistically, the topics where feedback is desired would have to be predetermined and would need to be limited to two or three issues, for example, information acquisition, information use, option formulation, the nature of transitions between topics of discussion, reconstruction of previously covered options, use of available resources and/or progressive deepening.

In this setting, the observer(s) would forego attempting to thoroughly map the entire process and would instead concentrate on tracking the specifically pre-identified issues of interest. Ideally, the analyzed data would be ready within 30 minutes for presentation at the AAR. This could include playback of specific audio (or video) taped segments to demonstrate particular points.

What we are proposing is a simplified variation of these methods for directly tracking key aspects of the progressive deepening in a natural setting. The products could then be used for immediate feedback for training.

We would expect the results to be helpful in the following training areas:

- The participants could see the process of how they managed the discussions and the group by how linearly both progressed. That is, while going to A, sidetracks X, Y, and Z were also taken.

- It would provide a framework to critique how they handled barriers encountered. That is, what were the barriers they did not consider, what were the barriers they became hung-up on, where information was needed but not gone after, ways they could have overcome barriers they were or were not aware of, etc.

We intend to develop such an after-action review technique as a follow-on project. The description of this technique and the results of its evaluation will be covered in a separate report.

CDM data training modules. In its non-abbreviated form, the CDM can be used to collect materials which could be compiled into training modules for classroom settings. The modules could include selected non-attributable excerpts from transcripts. These transcripts would contain examples of different types of transitions between topics, examples of options and information being "lost" due to distractions, progressive deepening charts to graphically demonstrate the nature of "growing a plan." They may also contain examples of distractions, redirections, and decisions, examples of places where additional information is needed and whether or not the planners actively sought out this information, and so on. The modules could be tailored for specific groups or constructed in a more generic fashion for broader audiences.

Develop a performance metric for group decision making. In general, the CDM is employed as a means of determining the nature of the decision processes and not as an evaluative tool with regards to the quality of the decisions. It could, however, be used to compile a metric of performance measures to evaluate the performance of planning groups.

These measures could be based upon information available from the application of the CDM. Examples include:

- How often they sought information when they needed it. How often they failed to seek it.

- Deliberate versus accidental inclusion of options. Many options are generated which become part of the plan. A select number of these are incorporated through the conscious desire of the planners. It appears that others become part of the plan almost by default (i.e., the planners become distracted and never return to their consideration of the option, never make any type of decision regarding it, yet it still finds its way into the plan). The ratio of deliberate versus accidental options included in the final plan could be determined.

- The number of "loose threads" that are still dangling when the plan is finalized (e.g., no decision was ever made about how to obstruct this avenue of approach).

- How the planners prioritized the use of the time available with respect to tasks to be accomplished. The battle managers we observed simply jumped into the process, started generating and evaluating options, and finished when they ran out of time. We did not see any attempts to manage the use of time. We did not observe anyone saying "we've got 5 hours here, and issues X, Y, and Z are the most important, so let's start with X but try to reach closure within 40 minutes." While it might be impossible to train people to be that rational, and it may even prove counterproductive, clearly there can be a better sense of directing the discussion to fit the priorities. If the ability to manage time comes from experience, perhaps it can be trained more effectively.

Summary

We studied three different battle management exercises in order to determine if the CDM interviews could be applied within a C^2 setting, and to try new techniques for collecting and analyzing data. We found that the CDM interviews were compatible with the constraints of military exercises. We also learned that certain CDM interview questions were redundant with information that could be collected by direct observation and taping of the planning sessions. We also developed micro-analytical techniques of data reduction: a five-hour planning session was analyzed into 64 segments and these were further categorized in terms of goals and processes. More interesting were the transitions between segments. Fully one-third were due to out-of-context interruptions, and planning rarely resumed from the point of the interruption.

We analyzed information sources and found that 93% of the information considered was directly available to the battle managers. There was little active pursuit of data, and not a single request for material from S2 (Intelligence) following the S2 intelligence update, which occurred two to three hours prior to the main planning. This is even more interesting in view of the fact that the planners repeatedly complained about the lack of knowledge of the enemy plans, intentions and attack routes.

The data we collected revealed a number of features of group decision making by these battle managers. We confirmed earlier findings about the reliance on recognition decisions and the infrequency of analytical decisions. Even though doctrine calls for concurrent deliberation, we found little evidence for it.

Instead, we saw a "satisficing" strategy marked by a one-at-a-time search for an option that would work and had no pitfalls associated with it. Therefore, training that emphasizes generating and evaluating sets of options may be counterproductive. Such training does not describe the performance of the decision makers we have observed, and it may reduce the credibility of the training program. In addition, decision support systems that promote the use of formal analytical methods are inconsistent with the decision strategies we observed.

We have proposed alternative concepts for decision support systems and training that we feel will be more consistent with the decision strategies that are being used.

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APPENDIX A
INTERVIEW GUIDES FOR OPERATIONS AND INTELLIGENCE

G3/S3 PROBES: Based on G3/S3 plans to this point.

1. What are the goals for the plan? Were there alternative goals?

2. What are the most important aspects/concerns you have about the current state of the plan? (be alert for X vs Y).

2a. How would you rank these concerns in order of importance for accomplishing the goals of the plan?

3. Did you consider other options/alternatives for the plan to this point? Was experience level a factor in the choice of alternatives? How?

4. What key factors do you feel helped or hurt your planning process?

5. Which factors/assumptions, if different, are critical enough to make the plan inoperative or inexecutable? (Xs and Ys)

5a. Rank these factors in order of importance for accomplishing the goals of the plan.

6a. Was there any material from briefings which you felt was particularly helpful to you in your job as G3/S3? Elaborate on reasons why helpful.

6b. Did any of this material from the briefings cause you to notice anything which you hadn't previously considered?

G2/S2 PROBES: Based on G2/S2 estimate of enemy plan to this point.

1. What are the goals for the plan? Were there alternative goals?

2. What are the most important aspects/concerns you have about the current state of the plan? (be alert for X vs Y).

2a. How would you rank these concerns in order of importance for accomplishing the goals of the plan?

3. Did you consider other options/alternatives for the plan to this point? Was experience level a factor in the choice of alternatives? How?

4. What are the key pieces of information you, as G2/S2, possess? (Xs and Ys).

4a. How would you rank these pieces of information in order of importance to the plan (our plan or the enemy's plan???)?

5. What key pieces of information do you feel are missing? (Xs and Ys).

5a. How would you rank these missing pieces of information in order of importance to the (ours or theirs??) plan?

6a. How much of all this information do you plan to report to G3/S3?

7. What key factors do you feel either helped or hurt your planning process?

8. Which factors/assumptions, if different, are critical enough to make the plan inoperative or inexecutable? (Xs and Ys)

9a. Was there any material from briefings which you felt was particularly helpful to you in your job as G2/S2? Elaborate on reasons why helpful.

9b. Did any of this material from the briefings cause you to notice anything which you hadn't previously considered?

Note: All probes with sub-letters (9a, 9b, 5a, etc.) are to be omitted first if available interview time is short.

APPENDIX B

SAMPLE OF TRANSCRIPT WITH SEGMENTS AND REFERENCE UNITS INDICATED

Segment Divider:
Reference Unit Divider: ------
Reference Units Numbered Along Left Margin.
Capital Letter/Colon (Z:) Indicates Speaker.

---

165 Z: Options sheet, don't blow all the bridges, we don't need to blow all the bridges, the ones to the north the ones to the south, why not try to force them to come through the center and the engagement area's here.

---

166 Y: I don't want to do that because I don't have anyone to stop them when they come through there, that's to give them an easy access, I want to make it as hard as possible, I just don't want to give...

---

167 Z: Their doctrine is they wouldn't take off along here, that's some fairly steep terrain through there, they take the high speed.

---

168 Y: But they are also, once our recon pulls back, they're going to have their scouts forward looking for those crossing and they're going to find them quickly and then they're going to see these blown and these blown, they're going to have to move through here and they're going to go that road as quickly as possible, slowing them down is what I want to do, that's why I'm blowing those and I'm going to leave these open for our guys to come through.

---

169 Z: That's where right in there and have them searching for a way around would be the place to drop your FASCAM, force them down here.

Y: Ok, but then we're going to go back.

Z: Option.

---

170 Y: I agree, that's an excellent spot, but it's not going to do us any good on our pass, cause there's not going to be anyone there to see it, unless we got a scout in town, we could tell them there is one scout we dropped off in the town or something like that.

Z: What I'm saying is, this is preferred, we just don't in that area, know what I mean, we drop it in there, 400 x 400 field.

---

171 W: You were talking that the bridges should already be precratered, it's just a matter of bringing up the stuff that's just means we need trucks. Does the engineer know that?

---

172 Y: Yea, we were talking about that.

Z: 400 x 400 field.

Y: We were talking about it, so . . .

Z: 400 x 400 field here, right, that's keep them from going that way for damn sure.

W: Sure will

---

173 Y: And then we need to deny them fast coming across this road.

Z: Then he can jerk his effort there, go a little bit down here.

Y: The only effort there is to drop the charges already have precratered bridge, that's all it is, is just to knock the bridge out, however we do it, whether we use. .

Z: I thought that was. . .

Y: That's a bridge, I pull it on mines, little boxes.

Z: Well, I look at minefields there I say well, hell, you move that minefield right down here and he will go ahead with the high speed avenue, once he's forced to the high speed avenue he'll take it. .

Y: Just ignore the boxes then, what that is a bridge and that's a crater, that's all I put there, cause I got to brief it so I just put those there to remind me.

---

174 Z: Col. will hit you on it.

Y: I'll probably get rid of them, cause he already told me about that .

Z: Col. likes detail, I've been working with him for years.

---

175 Alright, let's go ahead and put a fast unit in there 400 x 400 right there, you want to leave these open?

Y: No, I don't want to leave them open.

Z: Then it doesn't do them any good to throw FASCAMs there.

Y: Sure it does, cause they may come across and then they hit another mine.

---

176 Z: What I'm saying is, if you blow the bridges, alright, he's going to say screw that, he's going to look for a bridge, wouldn't do me any good to throw it there.

Y: How many do we have

Z: Cause it doesn't tie in with anything.

Y: How many FASCAMs do you have available.

W: Two. Possible 3. So to answer your question we need to find those 2 FASCAM spots.

---

177 Z: Oh he will want to use them

Y: I know.

Z: Doesn't mean that he's going to come in and just blow this plan all apart.

Y: He blows it apart that's fine.

Z: FASCAM in a big open area like that what does it do, does it tie in any engineer effort, does it block passage to the plans, does it channelize or deny him area, no. Take care of all of them your just mechanic.

Y: That's ok, I'm learning, I got more advice than I know what to do with, other than that.

---

178 W: Just tell me where you want my company.

Y: Originally we're going to set you up right in here, the 3s will be charlie is the way it goes, alphas will be 1s, bravos will be 2s and charlie's will be 3s. See initially be here, the engagement area is here, Col. want to defend in depth, then I've worked out a route, obviously when you get out there you will look for the best route back to attack.

---

179 W: My whole company out there?

Y: He wants a company positions here, if you want to maybe put two forward and then leave one back here we'll talk about it.

W: Where's that counterrecon going?

---

180 Y: You're going to come back here, basically I don't want to put anything in here other than just you might have a platoon up here, we were talking about that with two captains. Put a section or platoon up here if they use this road take them out in the open area, maybe put a crater in here. I put you over here because if they move through the woodline, as they come out of the woodline you may be able to get some shots with your defensive position, I need you to go out and look at that and see if that's going to be

viable, with your final position right here using the RR, I'm going to start ditching effort starting from the north, working down, so this will be your main engagement area here, bravo be in here, we'll have alpha and delta, and these are fall back, there's is no real fightable terrain in here, this is what we have to deny them, right here, autobahn. This is going to be all bogged up.

---

181 W: So why doesn't someone take this from me in the middle so I can take the north sector and worry about the north. Cause you got these guys doing nothing up front at least from the graphics it looks that way. Let them worry about picking up the guys in the middle and they can go back to positions you got me way. . .

---

182 Y: The reason I got them set here, see this plan obviously once it starts it may change, the reason I have bravo here is they're the anchor for the platoon, see their center sector.

APPENDIX C: CONTENT ANALYSIS DATA MAP EXCERPT

FOCUS/UNIT#	165	166	167	168	169	170
CMDRs Intent						
FR Strategy	FRst	FRst		FRst	FRst	
Timing						
Scouts				Scts		Scts
Obstacles	Obst			Obst		
Terrain			Terr			
Resources		Rscs				
Engineering						
Routes						
Positioning					Posn	Posn
E Strategy				Estr		
Other FRs						
Plan Process						
Soviet Doct			SDoc			
Logistics						
ARTBASS						ARTB
Weather						
Prob Recog						Prob
UNIT #	165	166	167	168	169	170
ACTIVITY DESCRIPTION	Option: dont blow all bridgs! Force E to center!	Dont want to give E easy access!	Sov. Doct! steep terrain!	Fr Recon pulls back, E Scouts Forward to see whats blown, etc!	Place to drop fascam!	Wont work! ARTBASS says have to have some-one to see! Could use Scout!
Segment Breaks 1=Hard; s=Soft	obstacles		enemy hypotheticals			
SEGMENT FOCI					OBSTACLES	
OPERATIONAL PROCESS DESCRIPTORS	GENERATE GENERATE	APPRAISE INFO APPRAISE	APPRAISE INFO APPRAISE	APPRAISE	GENERATE APPRAISE	INFO APPRAISE INFO GENERATE INFO GENERATE
GOAL CATEGORIES PER REFERENCE UNIT	7.3 4	4		3.11	4.12	
UNIT #	165	166	167	168	169	170
BREAKS (1) TRANSITIONS						

171	172	173	174	175	176	177
			CMDR	CMDR		CMDR
	FRst			FRst	FRst	FRst
Obst						
					Rscs	
Engr						
					Estr	
		Plan	Plan			Plan
		SDoc				
Logs						
				Prob		

171	172	173	174	175	176	177
Bridges pre cratered! Trucks to transport stuff! Engineer know?!	minefield!	Deny E road! Drop charges! bridges! minefield E routes!	Colonel not like!	Detail! Fascam limits!	E will go around blown bridges! How many fascam?!	Colonel will want fascam! Tie into engineer efforts!
obstacles		cmdr int		obstacles		cmdr int

CMDRs INTENT

APPRAISE INFO APPRAISE	APPRAISE APPRAISE	GENERATE APPRAISE INFO APPRAISE GENERATE APPRAISE CLARIFY	CLARIFY	APPRAISE APPRAISE	APPRAISE INFO APPRAISE INFO APPRAISE	CLARIFY APPRAISE
	4.12	4.12 4.11	8	4.12 8	8	6

171	172	173	174	175	176	177

178	179	180	181	182	183	184
FRst	CMDR FRst	FRst	FRst	FRst	CMDR FRst	CMDR FRst
Rtes Posn		Terr Engr Posn Estr		Posn	Estr	Posn

178	179	180	181	182	183	184
Company placement! Defense in depth! Routes out!	Company position!	Subsequent position! Primary positions! fightable terrain!	Co Cmdr discusses his Co's position options!	S3s rationale for placement!	Main Defense area! Cmdr redirects planning! Primary EA!	Cmdr gives main kill zone! Battle positions!

friendly strategy

ROUTES & POSITIONS

CLARIFY APPRAISE	GENERATE	APPRAISE GENERATE GENERATE APPRAISE	GENERATE APPRAISE	APPRAISE INFO	APPRAISE INFO APPRAISE	APPRAISE GENERATE APPRAISE APPRAISE DECISION REFINE
7	7	7.1 7.2 7.3	7	7	7	7 5

178	179	180	181	182	183	184
CQ					FC	